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Analysis of Traffic Accident In Addis Ababa: Traffic Simulation

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Abstract

This paper discusses the growing problem of road traffic crashes, particularly in Addis Ababa with particular reference to the magnitude, risk factors, interventions and research priorities. The 2004 World Health Report shows that of the 1.2 million people killed in road crash worldwide, 85% are in developing countries.

The traffic police reports human error, road environment and vehicle factors as the main causes of road crashes. However, little documentation is available on the broader underlying factors such as deficiencies in the breviaries changes, ineffective road safety legislation and enforcement, systems for data collection and management, and inadequate medical infrastructure for post-injury management. Although a variety of road safety interventions have been successfully applied, little attempt has been made to promote and implement them.

Every year, around 300 people are killed on Addis Ababa's roads and 1500 are light and seriously injured [Federal Police Central Bureau]. The governments have launched several campaigns, such as "Think!" and Road Safety Campaign (RSC), to help people become aware of road safety issues and try to reduce road accident.

This study tries to analyze the traffic accidents, and develop a computer-based traffic simulation for the route selection. This thesis has two main functions. Firstly, the aim is to provide users with an understanding of the major causes of traffic accidents and present using several Statistical tools. At the second function, it will apply an innovative, hybrid statistical model for route selection based on accident prediction to traffic police office data.

The system, if developed to include the whole network in Addis Ababa, will support several target groups, viz. all road users, Traffic Police and the Emergency and Fire Service through to insurance companies, and local government. The ideal system will

give people useful suggestions about how to improve road planning and traffic management.

In this paper, a survey is done on current prediction models and visualization techniques. A prototype system is developed using these theories. The functions in the prototype system are limited. More data is required to actualize the system on real terms.

The study consists of two major parts: the first part gives detail about the road traffic accident, and Ant Based Control Algorithm implemented for road traffic management. The second part, customization of research empirical equations and experiences to our local conditions and simulate/ forecast the future trend and also with the help of software developed, route selection at the pick hours is managed for the specific path in Addis Ababa.

In conclusion, the paper highlights the background of the growing problem of road traffic injuries in the city and provides some basis for optimism in tackling it.

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Acronyms

AADT	Annual Average Daily Traffic
ABC	Ant Based Control
AMF	Accident Modification Factor
ATC	Automatic Traffic Control
BAC	Blood Alcohol Estimate
CDS	Crash Worthiness Data System
DALYs	Disability Adjust Life Years
DOT	Department of Transport
DRIPs	Dynamic Routing Information Panels
FARS	Fatality Analysis Reporting System
FARS	Fatality Analysis Reporting System
FFS	Free Flow Speed
GES	General Estimate System
GNP	Gross National Product
GPS	Global Positioning Satellite
GRSP	Global Road Safety Project
IPIFA	Injury Prevention Initiative For Africa
MADD	Mothers Against Drunk Drive
MCC	Manually Classified Count
NASS	National Automotive Sampling System
NHTSA	National highway Traffic Safety Administration
O - D	Origin - Destination
PAR	Police Accident Report
PCU	Passenger Car Unit
PIA	Personal Injury Accident
RTIRN	Road Traffic Injury Research Network
VB	Visual Basics
VMT	Vehicle Mile Traveled
WHO	World Health Organization

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Chapter 1

1. Introduction

Everybody travels whether it is to be work, play shop or do business. All raw materials must be conveyed from the land to the place of manufacturing or usage, and all goods must be moved from factory to the market place and from the staff to the customer. Transport is the means by which those activities occur; it is the cement that binds the together the communities and their activities. Meeting these needs has been, and continues to be, the transport task. How people live and work has changed as a consequence of improvements in life style and in transport capabilities. What can be said with certainty about the future is that these interactive changes will continue, and that it will be the task of the transport planner and traffic engineer to cope with them.

Because of the pervasiveness of transport, solution to transport problems can have major influence upon people's lives. Transport engineering applies technological and scientific principle to the planning, functional design, operational and management of facilities for any mode of transport in order to provide for the safe, rapid, comfortable, convenient, economical and environmentally compatible movement of people and goods. Traffic engineer, a branch of transport engineering, deals with the planning, geometric design, and traffic operation of roads, streets, and highways, their network, terminals, abutting land, and the relationship with other mode of transport.

The first manufactured road were the stone – paved of Ur in the Middle East (4000 BC), the corduroy log path of Glastonbury, England (3300 BC), and the brick paving in India (3000 BC). A feature of Middle Age was the growth of many prosperous villages in to towns. Consequently, lengths of stone – paved street were constructed with some of the large towns. Long wagons - coaches were appeared in use in Spain as early 1546 to provide for long distance passengers travel. The development in Australia, in 1660s of the Berliner coach with its iron - spring suspension system led to the rapid expansion of

coach type travel so that, by 1750, four wheeled coaches and two wheeled chaises, introduced from France, had superseded the horseback – riding as the main mode of inter town travel.

Bicycling and motor vehicle begin innings: the Macmillan bicycle of 1839 is generally credited with being the first true bicycle; that is, its forward motion was obtained with pedal without the rider's feet touching the ground. Whilst there is some argument regarding the identity of the inventor of the first internal combustion engine, and then it occurred, there is no doubt but that the history of the motor vehicle really began in 1885 (in 1886, Karl Benz of Mannheim and Gottlieb Daimler of Constatt produce their first vehicle). Motor vehicle had little effect upon rural travel or town development for some considerable time. Until the introduction of the low – cost mass – produced Model - T car, by Henry Ford in the USA, prior to World War I, the motor vehicle was only enjoyed by the wealthy for the touring and pleasure – driving [1].

Accessibility and mobility are the key functions of transportation systems. Accessibility is the ability to reach desired goods, services, activities and destinations. Mobility is the movement of people and goods. Restrictions to accessibility and mobility, which can result from traffic congestion, have a profound impact on the national economy, quality of life, and the nation's safety and security. Intelligent Transportation Systems (ITS) and transportation analysis tools allow us to understand disruptions in transportation systems, predict effects, and therefore, mitigate the impacts of such events.

Road traffic injuries are a global problem affecting all sectors of society. To date, road safety has received insufficient attention at the national and regional levels. This has resulted in part from: a lack of information on the magnitude of the problem and its preventability; a fatalistic approach to road crashes; and a lack of the political responsibility and multidisciplinary collaboration needed to tackle it effectively. However, much can be done to reduce the problem of road crashes.

Indeed, many high-income countries have been able to reduce their road traffic injury burden by up to 50 per cent over the last few decades.

Despite the fact that the total number of reported accidents decreased the last few years, safety is one of the challenging issues in the transportation industry in Ethiopia.

The need to evaluate the impact of traffic signal (in the traffic network) on safety is the reason for developing a suitable methodology in this thesis in order to answer several questions on this topic. In this thesis, a safety model based on national accident database crash frequencies will be presented. The statistical accident rate model developed will include benchmark estimates of national rates of absolute crash risk by crash type and facility.

Traffic accident is the result of multiplicity of factors and it is often the interaction of more than one variable that leads to the occurrence of accident. Accidents occur as a result of the interaction of many different factors among which are road and traffic characteristics.

Most investigations have revealed that 70% to 80% of all traffic accidents are due to human error. The term human error however is often controversial for. It doesn't satisfactorily describe that large number of injuries and deaths that occurs on the road as the result of driving errors while abilities to do so are impaired by alcohol or drugs, lack of experience, lack at distribution of attention etc [14].

Car accidents are accidental collisions between automobiles. Car accidents can damage one or more autos, people, or structures. Car accidents--also called **traffic accidents**, **auto accidents**, **road accidents**, and **motor vehicle accidents**-- cause thousands of deaths and hundreds of thousands of disabilities each year. Worldwide, car accidents kill an estimated one million people each year [14]

Types of accidents

Car accidents fall into several major categories (whose names are self-explanatory):

- Rear-end collisions
- Side collisions
- Rollovers
- Head-on collisions

- Single-car accidents
- Pile-ups

A traffic accident is defined as any vehicle accident occurring on a public highway (i.e. originating on, terminating on, or involving a vehicle partially on the highway). These accidents therefore include collisions between vehicles and animals, vehicles and pedestrians, or vehicles and fixed obstacles. Single vehicle accidents, in which one vehicle alone (and no other road user) was involved, are included. All fatality and injury totals include pedestrians, motorcyclists and bicyclists unless otherwise noted.

Causes of accidents

Many factors result in car accidents, and sometimes multiple causes contribute to a single accident. Factors include the following:

- ❖ Driver distraction, including fiddling with technical devices, talking with passengers, eating or grooming in the car, dealing with children or pets in the back seat, or attempting to retrieve dropped items;
- ❖ Driver impairment by tiredness, illness, alcohol or drugs, both legal and illegal. **MADD** (Mothers Against Drunk Driving) is an organization made up of the families of the dead who were killed in car accidents caused by drunk drivers;
- ❖ Mechanical failure, including flat tires or tires blowing out, brake failure, axle failure, steering mechanism failure;
- ❖ Road conditions, including foreign obstacles or substances on the road surface; making the roads slick; road damage including pot holes;
- ❖ Speed exceeding safe conditions, such as the speed for which the road was designed, the road condition, the weather, the speed of surrounding motorists, and so on.

Most authorities emphasise speed as a primary cause of accidents, although most experts agree that speed alone rarely causes an accident. Some argue in favour of speed restrictions to mitigate the consequences of accidents, relying on Newton's law of momentum. That is, the outcome of an accident largely depends on the energy dissipated in a crash, and that energy rises as the square of velocity, according to the equation $E = 0.5mv^2$, where E is the energy, m is the mass, and v is the velocity. "Speed kills" proponents may also argue that slower driving causes no harm. On the other hand, critics

of the "speed kills" mentality claim that this argument ignores complex factors that influence accident outcomes, and thus fails to address the true causes of accidents. *Each year, an estimated 1.2 million people are killed in road crashes and up to 50 million injured worldwide.*

- (1) Road traffic injuries are currently ranked 9th globally among the leading causes of disease burden, in terms of disability adjusted life years (DALYs) lost. ***In the year 2020, road traffic injuries are projected to become the 3rd largest cause of disabilities in the world.***
- (2) Developing countries bear the brunt of the fatalities and disabilities from road traffic crashes, accounting for more than 85% of the world's road fatalities, and about 90% of the total DALYs lost due to road traffic injuries. The problem is increasing in these countries at a fast rate, while it is declining in all industrialized nations (Western Europe, North America, Japan, Australia and New Zealand).

The annual cost of road crashes is in excess of US \$500 billion, and in the developing world the estimated cost is about US \$65 billion each year. Due to the scarcity of costing data for African countries, it is difficult to make a precise cost of road crashes in Sub-Saharan Africa. The current estimate of costs of crashes in the continent is US\$ 3.7 billion per year, of which South Africa alone accounts for 2 billion. However, the estimated costs as a percentage of the national Gross National Product (GNP) in most African countries range from about 0.8% in Ethiopia and 1% in South Africa to 2.3% in Zambia and 2.7% in Botswana to almost 5% in Kenya [15].

1.1 Road Fatalities in Africa

A recent Global Road Safety Project (GRSP) study shows that about 10 per cent of global road deaths in 1999 took place in Sub-Saharan Africa where only 4 per cent of global vehicles are registered. Conversely, in the entire developed world, with 60 per cent of all globally registered vehicles, only 14 per cent of road deaths occurred. However, given the widely recognized problem of under-reporting of road deaths in Africa (like the rest of the developing world); the true figures are likely to be much higher, as the police-

reported road fatalities represent only the tip of the injury pyramid. According to this GRSP study, the adjusted true estimate of total road deaths for all Sub-Saharan African countries for the year 2000, based on the police department's records, ranges between 68,500 and 82,200. However, the estimated fatality figure of 190,191 for Sub-Saharan Africa presented in the 2004 World Report, based on health care data, is much higher, and reflects the magnitude of under-reporting in police statistics.

Two countries, South Africa and Nigeria, account for most of the reported deaths in Sub-Saharan Africa. The South African figure of over 9,000 has been consistent over time, while Nigeria with 6,185 deaths has declined from a high of over 9,200 in the early 1990s. **Ethiopia**, Kenya, Uganda, Tanzania and Ghana are the other countries that experience high numbers of road deaths [14].

1.1.1 Fatality Rates

There is no single accepted indicator that accurately describes the overall road safety situation in a particular country. The number of fatal crashes per million vehicle kilometres travelled per annum, as a measure of exposure to motor vehicle traffic, is the most common method often used in highly motorized countries. However, because of the absence of accurate data on vehicle usage in most African countries, it is not possible to apply this method. Instead, fatality rates, the number of reported fatalities per 10,000 registered motor vehicles, are normally used.

Fatality risk, calculated as the number of deaths per 100,000 populations per annum, which is also the indicator commonly used by the WHO and the ministries of health sector to report diseases and causes of death. It should be noted that both rates are subject to several errors, including variations in the definition of road deaths; under-reporting of crashes, the resulting injuries and deaths; lack of a uniform definition of a vehicle; inaccurate record of the total number of registered vehicles; and lack of accurate population data for the year of reporting. There are wide variations in fatality rates: from 270 in Central African Republic to 8 in Chad. The highest rates, all in excess of 100, are

reported in Ethiopia, Malawi, Tanzania, Uganda and Ghana. For most of the countries, the rates lie between 40 and 130.

1.1.2 Profile of Road Fatalities

Vulnerable road users - pedestrians, pedal cyclists and public transport passengers- are the most affected, and pay a heavy toll for their participation in traffic. Pedestrians account for the highest proportion of road fatalities in nearly all African countries, ranging between 31% in Zimbabwe and 51% in Ethiopia. Involvement of pedestrians is much greater in urban environment than in rural areas. Studies in Addis Ababa and Abidjan reported extremely high proportion of pedestrian casualties of 90% and 75%, respectively. Passengers rank second, accounting for 32% to 46%. Pedestrians and passengers altogether represent over 80% of all road deaths. Drivers account for a small share of fatalities, of less than 10 per cent. Among sub-Saharan countries, only South Africa has the largest share of driver fatalities (22%).

1.1.3 Sex and Age

As in other developing countries, males are over-involved in road traffic crashes and account for over 67% of those killed. This can partly be explained by their greater exposure to traffic as drivers and as frequent travellers in motor vehicles for work and leisure activities. Females are involved mainly as passengers and pedestrians. In Botswana, for instance, a recent study showed that females accounted for as high as one-third of all pedestrian fatalities and 43 per cent of all pedestrian casualties.

Over 75 per cent of road traffic casualties in Africa are in the economic productive age bracket of between 16 and 65 years. Those aged over 65 years account for a small proportion of road casualties, partly due to their small numbers in the general population. Children often get injured as pedestrians; up to 30% of Botswana's pedestrian casualties were aged less than 16 years.

1.1.4 Risk Factors

Reports for various countries (Kenya, Uganda, Ethiopia, Tanzania, Ghana, South Africa, and Zimbabwe) show that most of the road crashes are largely due to a range of human error, road and vehicle factors that include:

- 1) Over speeding, perilous overtaking;
- 2) Alcohol and drug abuse;
- 3) Driver negligence, poor driving standards;
- 4) Vehicle overload;
- 5) Poor maintenance of vehicles;
- 6) Bad roads and hilly terrain;
- 7) Negligence of pedestrians;
- 8) Distraction of drivers (e.g. speaking on cell phones).

These findings need to be taken with caution as the single causes usually reported by the police oversimplify the reality. Also, traffic police are often more inclined to cite the driver as being at fault than a pedestrian or cyclist because of the rules and guiding principles existing at this moment in time in Ethiopia, special investigation teams are needed to assess the contribution of the various risk factors at the time of a crash.

Special investigation teams are needed to assess the contribution of the various risk factors at the time of a crash. Although the factors cited above are the most commonly reported in routine police statistics, there are broader underlying inter-related factors contributing to the rising magnitude and burden of road traffic injuries in Addis Ababa.

These include:

- Rapid growth in motorization and human population;
- Increased spatial interaction of road traffic, in terms of the volume and direction of movement;
- Deficiencies and problems in road user behaviour;
- Conditions and environment of work in the public transport sector, with special reference to buses and *minibuses*;

- Social and economic conditions prevailing in Ethiopia;
- Serious deficiencies in the road network development and maintenance; and deficiencies in road safety planning, management, enforcement and interventions.

Firm political commitment and resources are needed at the national and international levels to effectively address these social, economic and developmental issues [15]

1.1.5 Road Safety Initiatives

Like in other developing nations, many African countries have established road safety agencies in form of National Road Safety Council or Road Safety Committee since the early 1980s, mostly within Ministries of Transport and Roads, with the aim of preventing road "accidents". They are intersectorial in composition, with membership derived from both governmental and non-governmental sectors, and operate mainly at the national level. Their roles and capacity to effectively function, however, vary from country to country. Activities includes:

- A. Ensuring law enforcement,
- B. Collecting road accident statistics,
- C. Revising traffic legislation,
- D. Promotion of road safety education,
- E. Ensuring adequate provision of medical facilities for traffic injury victims,
- F. Undertaking research in road safety, and co-ordination of all road safety activities.

In general, in Ethiopia – Addis Ababa, these organizations have largely been ineffective, as they do not have the capacity to function effectively due to inadequate funding, lack of sufficient human and material resources, as well as lack of authority to fully discharge their duties. A more effective central agency for road safety, with adequate resources and trained personnel, is needed in each Region.

1.1.6 Road Traffic Injury Research

There are some emerging initiatives to improve awareness and documentation of road crashes in Africa. The Injury Prevention Initiative For Africa (IPIFA), formed in 1997 by a small team of researchers, is exemplary. IPIFA is a non-profit organization with membership from 12 African countries (Uganda, Kenya, Ghana, Nigeria, Egypt, **Ethiopia**, Eritrea, Zambia, Zimbabwe, Mozambique, South Africa and Mauritius).

The aims of IPIFA are to conduct research in injury control and promote safety, develop and conduct training programs in injury epidemiology, prevention and acute care; undertake advocacy for the prevention and control of injury; facilitate the exchange of knowledge in Africa, and act as a liaison between Africa and international and continental stakeholders in injury control. IPIFA has taken on the challenge of injury control on a continent where the problem is largely unrecognized and where the magnitude of the problem has been demonstrated to be huge.

IPIFA works closely with the WHO and Global Forum for Health Research, and has received considerable financial support from these organizations. Other institutions and organizations, which have provided funding for injury research to IPIFA, include the Graduate Institute of Geneva on Small Arms Survey and the Road Traffic Injury Research Network (RTIRN). In addition, individual members of IPIFA have been able to win competitive research awards from various agencies such as the National Institutes of Health, Center of Disease control (CDC), Rockefeller Foundation, and the Volvo Research Foundations.

The key research areas identified through these initiatives encompass the following topics: **Pedestrian and cyclist mobility, Policy issues and Emergency medical systems.**

The Future - According to a World Health Organization/World Bank report "The Global Burden of Disease", deaths from non-communicable diseases are expected to climb from 28.1 million a year in 1990 to 49.7 million by 2020 - an increase in absolute numbers of

77%. Traffic accidents are the main cause of this rise. Road traffic injuries are expected to take third place in the rank order of disease burden by the year 2020.

"The Magnitude of the Problem" - On average in the industrialized countries, and also in many developing countries, one hospital bed in ten is occupied by an accident victim. Traffic accidents are a major cause of severe injuries in most countries. Developing countries have nearly four times the number of deaths from these causes as the developed world.

According to the WHO, Ethiopia has the highest rate of fatalities per vehicle in the world. Uganda ranks second in road fatality rates in the world behind Ethiopia. Emergency medical systems are often poor and injury prevention programmes are rarely available [14].

Road traffic accidents currently kill 1,800 Ethiopians a year and injure another 7,000. Alarmed by the increasing carnage, Shell Ethiopia, the largest fuel distributor in Ethiopia with a 43 % market share, launched an awareness campaign: "Drive to Live". The campaign is intended to promote the value of safety rules and the benefit of implementing "defensive driving" for drivers employed by the transport companies.

It was reported that the Road Transport Authority of Ethiopia had imported four patrol cars to police traffic in the capital, that trap for over speeding, although It is not realized – the future hope.

In Ethiopia, The capital Addis, there were different workshops and presentations had been coordinated and conducted to respective authorities, aimed global initiative in benchmarking road-traffic enforcement through international sharing of good practices and successful implemented enforcement strategies.

The Conference laid special emphasis [13].

- In re-defining the enforcement with current relevance;
 - In suggesting the role and coordination of responsible agencies in enforcement;
 - Definition and allocation of traffic related fines;
-
-

- Accident Investigation and Analysis as a core issue to understanding the complex issues relating to enforcement;
- Legislation for important enforcement issues like: dangerous driving, driving under the influence of alcohol and drugs, over-speeding, school transportation, parking, protection for two wheeler riders etc;
- Tools and systems for effective enforcement;
- Infrastructure for enforcement;
- Expertise and Skills for enforcers;
- Driver Training;
- Vehicle Certification and enforcement;
- Public dealing;
- Crisis Management and handling of collisions;
- Global coordination and dissemination of best practices.

1.1.7 The Burden and Trends of Road Traffic Injuries in Developing Countries

Why still the road traffic accident increases? Why so many accidents?

The social and economic costs of road traffic injuries are enormous. The annual loss to developing country economies, due to road traffic injuries, is estimated at US\$ 100 million. This figure is about twice the total official development aid and loans these countries receive [13]. These cost estimates do not include social and psychological costs associated with death and disability from road traffic injuries, regardless of where they may occur.

The fatalities and injuries due to road traffic crashes in developing countries are rising, fueled by rapid growth in motor vehicle numbers. In Ethiopia, for instance, four-wheel motor vehicles increased by 3 per cent per year [13].

1.2 Facts About Addis Ababa City Transport

1.2.1 Background

Ethiopia is one of those developing countries with low level of income accompanied by high rate of population growth. As part of the developing world, Ethiopia is predominantly an agrarian country with low level of urbanization. The economic performance of different sectors of the national economy is very low. This low performance is due to a number of constraints such as low level of investment in different sectors of the national economy. Among these the existing transport could be mentioned as one. Transport is an important sector for facilitating different economic activities in the national economy.

Nevertheless, due to low level of urbanization and the poor performance of the economy, transport could be said to be at its infancy stage in Ethiopia .The modalities of transport mobility are limited. The greater percentage is covered by the natural mode of walking and animal transport system leaving only a very negligible share for the motorized.

According to the 1994 population and housing census result, its population is estimated to be 63 million. There are 926 urban centres in the country out of which only 302 urban centres are designated with municipal status (Central Statistical Authority). Among all the urban centers Addis Ababa is the largest urban centre, accounting one third (around 28 percent) of the total population of all the urban centres [13].

1.2.2 General Conditions of Traffic and Transport Development

Addis Ababa is the seat of government of the Federal Democratic Republic of Ethiopia (FDRE). It is also home to the African Union, the Economic Commission for Africa and other international organizations. For administrative purposes Addis Ababa is divided into 10 ‘Kefle Ketemas’. Hence, Addis Ababa has a significant contribution in the economic, social and political sector development of the country. Over the past years the city of Addis Ababa has witnessed with an amazing expansion of the city size.

Located at heart of the country with population of 3 million and Addis Ababa has a total land area of 54,000 hectares. The rapid increase in urban population with an annual growth rate of 3.8 percent per year has not been provided with an equal growth in urban transport provisions. .

A mixture of ownership structures, of which public and private operators are predominantly contenders for business, carries urban transport in Addis Ababa. The modes of urban transport system in the Addis Ababa are categorized in to motorized and non- motorized traffic. As such the modes of transport include public bus; minibus; taxis and the non-motorized transport, while walking and animal carts dominant the periphery. Currently, taxis, city bus and private cars altogether cover 30 percent of the urban mobility, that is, 26% bus, 72% taxis and 4 % private cars. While 70% of urban mobility is covered on foot [12].

For the year 2003, Addis Ababa's budget amounts to about 2.8 billion Ethiopian Birr of which 1.1 billion is recurrent budget and 1.7 billion is capital budget. The share of the Transport Authority is about 20, million Ethiopian Birr. According to the 1994 urban household survey data, the average monthly income of 47 percent of the household had a monthly income of less than 300 Birr.

Many of the traffic congestions and road safety problems in Addis Ababa may be attributed to inefficient use of road networks, weak enforcement capability and poor design of roads. As such Road Traffic Safety Regulations have been issued in the 1998 by the Council of Addis Ababa Administration. Accordingly, who so ever, by omission, contravenes what is laid down depending on the gravity of the offence committed is obliged to be punished.

1.2.3 Basic Indicators for the Description of Urban Mobility

Addis Ababa transport has special characteristics of its own. The foundation of the city in 1886, the broad physiognomy of a radial road system had evolved focusing around the centre. The radial system, which consists of 5 main arterial roads. Besides their national and regional level functions also ensure connection and accessibility to new expansion

areas. A combination of these radials with a set of ring roads has been envisaged so as to minimize travel distance, time and energy consumption to discourage long-distance traffic from passing within the city centre.

Today, the total length of road in the city is 1, 329.59 km, out of which 29.7 percent or 395.27 km is asphalt road; the remaining 70.03 percent or 934.34 km is non-asphalt. Road gross density is 1.45 percent, which is including asphalt and non-asphalt roads adequate to support the smooth running and development of the socio economic and physical integration of the city.

As modernization and consequently the urbanization moves forward, the use of motorized transport to maintain the socio economic and physical integration of the city increases. Currently city buses, taxis and private cars altogether cover only 30 percent of the total urban mobility. While 70 percent of the urban mobility is covered on foot. The rise in automobile ownership although not yet very significant together with the poor condition of the roads and the poorly functioning traffic system have resulted in high level of congestion particularly at peak hours.

The vehicle fleet in Ethiopia is estimated to be 1.3, 000 vehicles in 2002 composed of 39,200 private cars, 21400 trucks (dry and liquid cargo) 13200 Government vehicles, 12600 buses, 10,000 taxis, 5200 international vehicles and 1600 motorcycles. The greater numbers of motor vehicles are found in Addis Ababa with a total share of 77 percent of the total motor vehicles. Thus Addis Ababa had 21, 31 motor vehicles per 1000 from the year 2002 to 2003. Where annual motorization rate of the city had been 5.8 percent on the average.

1.2.4 Main Problems of Traffic Development in Addis Ababa

The rate of traffic accidents and pollution in Addis Ababa goes up together with the increase of motor vehicles and population size. The rise in automobile ownership together with the poor condition of the roads has resulted in the high level of traffic safety and congestion problems. Despite it has low level of motorization; the share of the city in the total number of accidents was 60 percent in 1989 and 55 percent on the average from 1986-2002. During this period, annual average traffic accident growth had been 31.4

percent. Besides, the increase in car traffic has resulted in an increase in air and noise pollution of the city. More than 12, 000,000 Ethiopian Birr is being lost every year because of traffic accidents. Thus the rise in automobile ownership together with the poor conditions of the road has resulted in high level of traffic safety and congestion problems.

In general the major transport problems in Addis Ababa include among others:

- Shortage and low quality of transport services and facilities
- Poor quality of roads, pedestrian walkways
- Low affordability level by most urban citizens
- High rate of congestion at peak hours and hence high rate of traffic accidents
- Lack of lane animal transport, bicycle and pedestrian

More over, the high unemployment rate, the rising household size and the low-income level negatively affect the demand for motorized transport. City bus transport is the second cheapest mode of transport next to walking. The fact that the revenue it generates doesn't cover its costs and that even the subsidized fares are unaffordable by the majority of the citizens are the major challenge [12].

1.2.5 Main Targets of Traffic Polices and Practice

The urban transport system could be viewed as a nervous system whose proper functioning is central to the overall well being and functioning of the city. In view of this the main target of traffic police in Addis Ababa include:

Improvement of infrastructure facilities: There are good opportunities in the existing land tenure, liberalization and decentralization policies that could be utilized to improve the situation of mobility in Addis Ababa. Upgrading of slum areas with main focus on the infrastructure (road access provision) should be promoted in order to improve accessibility and the safety of the living conditions for the poor.

In this regard, a city ring road is one of the major on-going projects, phase I and II of this ring road is under construction while the 3rd is under study. This road is expected to

facilitate the flow and accommodation of more traffic and hence lessening the effect of congestion on mobility.

- **Involvement of the Private sector and seeking international partners:-** With the ongoing privatization process and the government's strong orientation towards enabling the private sector, possible and effective areas of action could be identified and built upon. The private sector should be mobilized to provide services within a competitive framework. The public sector might be limited to ensuring the process to meet social and environmental objectives for example by controlling fares. The city government is showing interest in this direction. To improve the situation, donors could also take part in promoting these varieties initiatives Donors can take part in the actual physical provision of services and facilities such as equipments in the development of traffic regulations and management systems, through different institutions and arrangements as deemed appropriate.
- **Appropriate policy and programmes:-** Traffic management is crucial and thus should be given importance to improve the movements of people and goods; to ensure efficient and safe access and distribution; alleviate traffic congestion and adverse traffic impacts arising from major land use developments. Construction of new roads in the new development expansion areas, enhancing the capacity of the existing roads, and improvement of the drainage system, improvement of road and transport facilities, increased involvement of the private sector are among the major direction of the Addis Ababa Transport Authority.

These strong initiatives could be fostered towards practical actions if appropriate tools and implementation are put in place. Increasing the number of buses for mass transport, provision walkways and thoroughfares, road maintenance and redesigning and reconstruction of critical junctions and squares could help ease the problem of traffic congestion, The application of road changes and taxes can help correct subsidizing private motor vehicles. Creation of an enabling policy environment and provision of facilities such as parking spaces, terminals etc. and limiting the non-motorized ones to specific route could be recommended as a viable strategy.

Was there a Planning Strategy to reach these goals?

Addis Ababa is a metropolitan city where there is rapid growth of population increasing number of vehicles moving in it and it is a centre of many business activities. Besides, Addis Ababa is a seat of many national and international organizations like organization African Unity and the Economic Commission for Africa. Hence, the promotion of modern urban transport and traffic management is indispensable for the purpose of ensuring sustainable urban transport development. In the past Five –Year Development Programme (2001-5) the Addis Ababa City Government has developed a strategy to deal with transport issues. The main concerns of the strategy are:

- ✓ To increase the number of buses;
- ✓ Encourage more involvement of private sector in the provision of the city bus and taxi services, management of park meters, park lots, drivers training,
- ✓ Improve road utilization culture through mass media campaign to remove traffic flow obstructions
- ✓ Improve transport utilities by construction of terminals and installation of park meters for charging street side parking.

The Need for Computerization

Currently, the Addis Ababa City Transport Authority maintains a large volume of drivers, Vehicles and other data on manual files .In order to improve data management there is a need to computerize the system however; there is financial limitations to do so.

Human Resources Development

In order to enhance urban transport sector efficiency the requirements of skilled manpower is indispensable one. Particularly we need to develop our staff in transport planning and engineering;

Traffic management, in Information Science and transport management, and so on, however, there is shortage of financial resources

Road Safety

Among the many causes, road accident is identified to be the major cause of death for economically productive portion of the population in Addis Ababa. Traffic accident rate in

the city is high which covers 60 percent of the total accident occurred in Ethiopia. This is due to:

- ✓ In adequate drivers' training and public awareness on traffic safety
- ✓ Inadequate traffic facilities such as traffic lights, signs, signs crossing marks
- ✓ Ineffective and inefficient traffic regulations there is weak traffic management in the city.

As the issue of road safety is vital by its virtue it needs a special treatment in order to save the lives of citizens. To this effect ample financial resource is required where developing countries like Ethiopia are lacking [12].

1.3 Background

Motor vehicle traffic accidents in Addis Ababa during the year 2000 – 2005 is about 44,000 and this figure is relatively less compared to the years 1985 – 1997. During the period of 1985-1997 there were more than 50,000 crashes in the Addis Ababa (traffic police report: 1997). An average approximately 3000 crashes are reported to the police each year. Note that there is still gap between the actual accident and recorded data.

A mixture of ownership structures, of which public and private operators are predominantly contenders for business, carries urban transport in Addis Ababa. The modes of urban transport system in the Addis Ababa are categorized in to ***motorized and non- motorized traffic***. As such the modes of transport include public bus; minibus; taxis and the non-motorized transport, while walking and animal carts dominant the periphery. *Currently, taxis, city bus and private cars altogether cover 30 percent of the urban mobility, that is, 26% bus, 72% taxis and 4 % private cars, while 70% of urban mobility is covered on foot.*

As modernization and consequently the urbanization moves forward, the use of motorized transport to maintain the socio economic and physical integration of the city increases. The rise in automobile ownership although not yet very significant together with the poor condition of the roads and the poorly functioning traffic system have resulted in high level of congestion particularly at peak hours., whereby

the probability of occurrence of accident is very high. The vehicle fleet in Ethiopia is estimated to be 197,509. Those vehicles as of 2002 reports are composed of 70,972 *private cars*, 72,024 *trucks (dry and liquid cargo)* 30,367 *Government vehicles*, 16,064 *buses*, 17,253 *taxis*, 10,091 *international vehicles* and 1600 *motorcycles*. *The greater numbers of motor vehicles are found in Addis Ababa with a total share of 77 percent of the total motor vehicles. And annual motorization rate of the city had been 5.8 percent on the average [13]*.

1.4 Statement of the Problem

Ethiopia, one of the poorest countries in the world loses 400 million Birr each year due to road accident (which were 12 million Birr / years, 15 years ago). This doesn't include the socio economic costs associated with the accidents. This alarming accident rate is recorded as the third killing vector in the past years. Even those figures declared based on statistical data from the authoritative showing a very hazardous situation, however there doesn't seem a sufficient work being done to reduce this alarming accident rate.

The rate of traffic accidents and pollution in Addis Ababa goes up together with the increase of motor vehicles and population size.

"...many countries in Africa, including Ethiopia, had extremely high accident rates. The death rates per vehicle can be in the order of 50 times that of European countries. "We urgently need to address this issue." In fact it has been predicted by the World Health Organization that unless the country takes urgent action road accidents will become one of the top causes of death within the developing world" [12].

Reports from the statistical data (Addis Ababa Traffic Police Central Bureau) show the following;

- In Addis Ababa City, annual average traffic accident growth had been 8.75 for the years 2000 to 2005, which is One – Third of the whole of accidents register in Ethiopia on the same years.
- 288 lives and 15,850,618.5 amounts in ETB, lost on an average from 1996 to 2005.

- Insurance Claims as a result of traffic accidents
 - Nile Insurance:
 - Paid about 20 Million ETB, from the 29.4 Million ETB claimed from clients, in 2002.
 - Awash insurance:
 - Paid 12 Million ETB, from a claim of 17 Million ETB, in 2002.

In general, the major transport associated problems in Addis Ababa include among others:

- Shortage and low quality of transport services and facilities
- Poor quality of roads, pedestrian walkways
- Low affordability level by most urban citizens
- High rate of congestion at peak hours and hence high rate of traffic accidents
- Lack of lane for bicycle
- Traffic road signs / signals invisibility and lack of planned maintenance
- Drivers and pedestrians behaviours and knowledge on road safety
- Poor and traditional procedures of vehicle maintenance, mostly in independent workshops

1.5 Objectives of the Thesis

The general objectives of the study is:

To model Road Traffic road Accidents in Addis Ababa, limited to the selected routes, and use the models to forecast future traffic accidents.

To identify the most severe road segment and simulate route selection based on the traffic density and accident risks.

The specific objectives are:

- ✓ To emphasize accident relation to road signs and traffic signals that is not positioned on a clearer and visible manner.
- ✓ Based on the material collected from the various sources available, to prepare summary tables presenting available data about motorization, fatalities, injuries, economic losses and accident trends.
- ✓ To save community lives and properties, that could have been lost due to the traffic accidents, by creating road traffic awareness
- ✓ To keep roads adaptable for transportation, with improved and planned maintenance
- ✓ To show the importance of pedestrian passage to effect on traffic accident control.
- ✓ To create public awareness on the road safety, and Defensive Driving
- ✓ To guide all vehicle maintenance workshops in adopting licensed maintenance procedures.
- ✓ To show the impact of importing used vehicles contribution on the traffic accidents
- ✓ To assist the regulatory body in structuring rules and regulations
- ✓ To Stress on cost / benefit analysis on implementing proactive measures and recommendations from the results of the study.
- ✓ To demonstrate the feasibility of the approach using field data and traffic simulation.

1.6 Opportunities to accomplish the Research

The worldwide nature of the problem and one of the key concerns of our Government list includes the issue of Road Traffic Accident, it makes the research work done on the subject very demanding. Also, Offices and Government authorities are very cooperative in any activities regarding Traffic Accident. Thus, collecting the data and discussions with the respective divisions become easier. There are some literatures and documents on the subject based on Addis Ababa Context, and the Whole of Ethiopia. Students from different Institutes are also focusing on the issue of road transport related problems, thus there is a big opportunity of multidisciplinary grouping to tackle the problem.

1.7 Limitations and Assumptions

There are limitations on the thesis, mainly on time restriction to collect actual data like traffic density, traffic flow (volume) and format / availability of data required for the research work. Data from the Addis Ababa Traffic Police Central Bureau is in the form of Hard copy, and it makes very difficult to collect accident rate for each segments in consideration. Therefore only one-year data, 2005, is used as a base in segment risk comparisons.

Budget Constraints forces the researcher to use manual counts for the vehicle density, which may have human error and could not possible to capture the vehicle speed with in the selected range of time.

Therefore, to implement the proposal one have to verify all the collected data and refine the assumptions taken. Assumptions adapted on this thesis are the state of vehicle condition; road parameters and drivers behavior remains constant. Data Collected for the previous week used for the route selections on the following week. Data updating on the software, developed to support the thesis, are on daily basis for the maximum and minimum densities.

In order to forecast the future accident for the selected routes, some variables in the base Equation are set on assumption based.

1.8 Expected benefit of the Thesis

The primary benefit of this research is to provide a tool that enable user to make better decision while planning to make any movement so that either the risk of being victimized with road accident or trapped traffic jamming will be minimized.

The user is able to fix his travel time and the source and destinations, thus the possible minimum distance, or minimum time alternative routes could be selected.

Furthermore, the research helps for the responsible authorities to see the effect of how sever the issue is, such that great attention and participations on any research based on transport accident related problems will be supported efficiently. In addition, it is also a supporting document for a research on the title.

1.9 Thesis organization

Following this chapter, *chapter 2* provides a summary of the available literature in the area of safety and more specifically in the development of accident models, and accident rates. Also in chapter 2 is a brief summary of the existing accident databases. The databases serve as a main source for extracting crashes from them in order to develop crash rates. These crash rates need two major variables: the crash frequencies (are obtained from the crash databases) and the vehicle miles travelled figures (obtained from the Roadway Statistics). *Chapter 3* presents the sources of data used for the development of the crash rates.

Sources such as the roadway statistics and extracted data from the traffic database will be analyzed in order to present the foundation of the safety model that follows. Chapter 3 also includes the various accident trends for the year 1996 – 2005, because these will be used as a benchmark in order to validate the results that will be presented in chapters 4 and 5.

Chapter 4 focuses on the database and the development of the accident rates that are used in chapter 5. Chapter 4 provides information for the database, the extraction process and the reliability of the estimates. Also in this chapter is a description of the database variables and accident rates produced. The raw accident rate data that the safety model utilizes are also presented.

Chapter 5 and chapter 6 present a description of the safety model and the equations that were developed. Also in chapter 5 is the evaluation of the safety model in both a field data and micro-simulation evaluation.

Chapter 7 provides the Visual Basic code and user-friendly software development, in order to select the route based on either shortest route or traffic density and risks in to consideration.

Finally, *chapter 8*, conclusions from this study as well recommendations and further research hints are stated.

Chapter 2

2. Literature Review

2.1 Introduction: Definitions

This chapter presents some background information of the available literature related to the development of accident rates, accident models and accident statistic databases. The first section deals with the major national accident databases and the second with other existing accident databases. The third section focuses on a brief description of the highway statistics available while the fourth section deals with some recent research on the development and comparison of various accident rates. Finally, the fifth section deals with studies related to the development of accident models.

What is traffic?

Traffic can be defined as the movement of pedestrians and goods along a route, and in the 21-century the biggest problem and challenge for the traffic engineer is often imbalance between the amount of traffic and the capacity of the route, leading to congestions. Traffic congestions is not a new phenomenon. Roman history recorded that the streets of Rome were so clogged with traffic that at least one emperor was forced to issue a proclamation threatening the death penalty to those whose chariots and cars blocked the way. More recently pictures of our modern cities taken at the turn of the century show clogged with traffic.

The dictionaries define “traffic” as the transportation of goods, coming and going of persons or goods by road, rail, air, etc.

Traffic engineering deals with the traffic planning and designs of roads, of frontage development and of parking facilities and with the concern of traffic to provide safe, convenient and economic movement of vehicle and pedestrians. Traffic engineer is used to either to either improve an existing situation or, in the case of new facility, to insure

that the facility is correctly and safely designed and adequate for the demands that will be placed on it.

A traffic accident is defined as any vehicle accident occurring on a public highway (i.e. originating on, terminating on, or involving a vehicle partially on the highway). These accidents therefore include collisions between vehicles and animals, vehicles and pedestrians, or vehicles and fixed obstacles. Single vehicle accidents, in which one vehicle alone (and no other road user) was involved, are included. All fatality and injury totals include pedestrians, motorcyclists and bicyclists unless otherwise noted [1].

The accident databases needed to be investigated further in an effort to choose the most complete database that will provide the crash frequencies. As mentioned earlier, the safety model will utilize accident rates in order to produce the accident risk of a facility based on its free-speed. Therefore, some recent papers on the development of accident rates are presented in this chapter. Some of the accident models developed by various research groups are presented below to demonstrate the fact that most of them refer to a limited amount of variables.

In this section, the major accident statistic databases are reviewed. The level of exposure makes these databases very important when compared with local databases. The largest and most complete accident database, available, is the Federal Traffic Police Fatality Recorded Data, which was extensively used for the development of this thesis. Other major databases include the Fatality Analysis Reporting System (FARS). These databases will be described in further detail in this chapter.

Figure, below illustrates the various accident databases, used in most of developing countries that will be described below.

This thesis will use the results extracted from the General Estimates System (GES) database, together with some literature sources, in order to construct the statistical foundation for the development of a safety model.

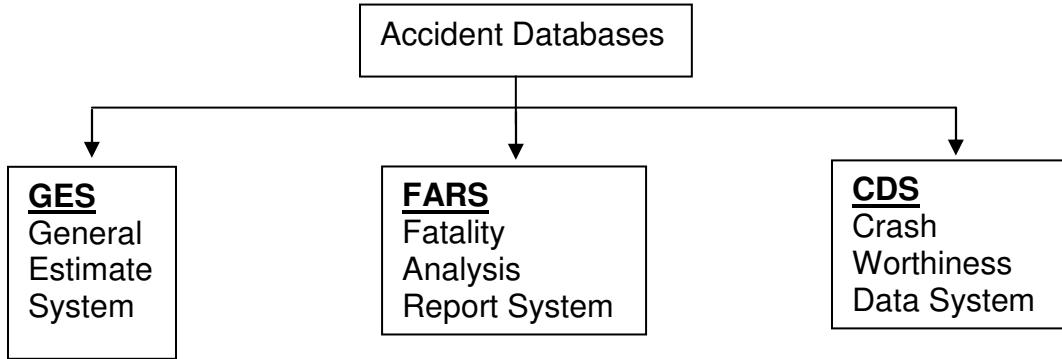


Figure 2.1 Accident Data bases

This thesis will use the results extracted from the General Estimates System (GES) database, together with some literature sources, in order to construct the statistical foundation for the development of a safety model [18].

The safety model will utilize the accident rates as an input in order to calculate the accident risk on a certain facility. The biggest accident database with accident data will be used for the purposes of this thesis. Crash databases do not quantify the impact of traffic signal coordination on crash risk. However, these databases can serve as a benchmark for the evaluation of some alternative approaches such as modelling studies.

At this point, it must be noted that two terms are used in this thesis to describe a collision: accident and crash. Some authors avoids using the term “accident” which suggests that an incident is due to random forces of nature. A “crash” on the other hand can be prevented or mitigated through driver, vehicle, roadway or environmental interventions

2.1.1 General Estimates System (GES)

The General Estimates System (GES) database was developed in 1988 by the National Center for Statistics and Analysis and is operated by the National Highway Traffic Safety Administration (NHTSA). GES data are obtained from a nationally representative probability sample selected from all police-reported crashes. Primary objectives for the

development of this system were the identification of traffic safety problem areas and for the database to be used as a basis for benefit/cost analyses of traffic safety initiatives.

The level of exposure makes GES, the largest accident database available in the United States. Due to its level of exposure, Department of Transport - DOT agencies, lawyers, doctors, researchers and insurance companies use it extensively. By using the database one can estimate different accident frequencies (number of vehicle crashes). For a crash to be eligible for the GES sample, it has to meet a number of criteria including:

Police Accident Report (PAR) must be completed, It must involve at least one motor vehicle travelling on a traffic way and the result must be property damage, injury or death. More detailed information as to how the data are grouped and how the national estimates are produced will be discussed in Chapter 3.

The crashes in the database are classified in a variety of ways, for example by a typical speed limit, accident severity, time-of-day and vehicle type. A statistical model that the database utilizes enables the user to extract national statistics on accident frequencies. There are three main files (Statistical Analysis Data Sets) in the GES database that include all the variables. These files contain the following:

Accident file: contains information describing environmental conditions and roadway characteristics at the time of the crash. It includes information such as the time the crash occurred, the manner of collision and speed limit of the facility that the crash occurred.

Vehicle/Driver file: contains information describing the vehicles involved in the crash and their drivers. It includes information such as the model/make of the vehicle, model year of the vehicle, driver manoeuvred to avoid, and driver distracted by.

Person file: contains general information describing all persons involved in the crash: drivers, passengers, pedestrians, pedal cyclists and non-motorists. It includes information such as age, sex and injury severity.

2.1.2 Fatality Analysis Reporting System (FARS)

The Fatality Analysis Reporting System (FARS) was conceived and developed by the National Center of Statistics and Analysis (NCSA) in 1975. It contains data on all fatal traffic crashes. FARS was developed in order to assist traffic safety professionals in identifying traffic safety problems and evaluating motor vehicle safety standards and highway safety initiatives.

The so-called FARS forms are completed, which include the following information:
Police Accident Reports (PARS), Driver licensing files, Vehicle registration files,
Highway Department data, Vital Statistics, Death Certificates
Hospital/Coroner/Medical reports

In order for a crash to be included in FARS, it must involve a motor vehicle travelling on a traffic way and result in the death of a person (either an occupant of a vehicle or a non-motorist) within 30 days of the crash. Detailed descriptions of each fatal crash reported are included in FARS files. For each case more than 100 coded data elements that characterize the crash are included. These include elements that characterize the crash, the people involved and the vehicles. In greater detail, the data elements are reported on four forms as follows:

Accident form: contains the time and location of the crash, first harmful event and the number of vehicles and people involved. Vehicle and driver forms: contains data for the vehicle type, most harmful event, drivers' license status and initial and principal impact points.

Person form: contains data on each person involved in the crash, such as age, gender, and role in the crash, injury severity and restraint use. Finally, FARS incorporates a variety of information on alcohol related crashes with data such as overall crash alcohol estimates and driver and non-occupant Blood Alcohol Estimates (BAC) [25].

2.1.3 Crashworthiness Data System (CDS)

The Crashworthiness Data System (CDS) was developed by the National Automotive Sampling System (NASS) in 1979 through NHTSA, an agency of the U.S. Department of Transportation. A random sample of thousands of minor, serious and fatal crashes is selected for study. Field research teams study crashes involving passenger cars, light trucks, utility vehicles and vans each year. Research teams further examine each particular case in order to obtain data and evidence of skid marks, fluid spills, bent guardrails and broken glass. The crash damage is then measured and the teams photograph the vehicles. Interviews with crash victims follow and the nature and severity of injuries is determined.

All the collected data by the research teams become permanent NASS reports. CDS is then used by the NHTSA for a variety of purposes such as the identification of potential preexisting traffic safety problems. The data are also used for the evaluation of vehicle safety systems and designs. Another important area where the CDS is very useful is to examine the relationship between the type and seriousness of a crash and the resultant injuries.

2.2 Highway Safety Information System

The Highway Safety Information System (HSIS) was developed by the Federal Highway Administration (FHWA). The FHWA proceeded in the development of this database due to the need for a database that would serve as a tool to assist highway engineers and administrators in the decision-making process. The need for an understanding of how safety is affected by the geometric design of the roadway, the use of traffic control measures and the size and performance capabilities of the vehicles led to the development of the HSIS.

In brief, some of the data files include the following information:

- Crash: contains type of accident, vehicle types, sex and age of occupants, accident severity and weather conditions.

- Roadway Inventory: contains information for types of roadway, number of lanes, lane width, rural urban designation and functional classification.
- Traffic Volume: contains Annual Average Daily Traffic (AADT) data.
Intersection: contains traffic control type, intersection type, and signal phasing and turn lanes.

The above data can be used to analyze many safety problems. Modeling efforts to attempt to predict future accidents through roadway and traffic factors can be one application where the HSIS can be very beneficial. In terms of the extraction of data, the Statistical Analysis System (SAS) format is used, as is the case in the GES Database. Only police reported accident data maintained highway system are included in the HSIS [18].

2.3 Road Safety

There are three factors that result in accident: [appendix A]

1. Road and environment deficiencies
2. Road user errors (human factors)
3. Vehicle defects.

Road and environment deficiencies account on their own only for only 2% of all accidents but in combination with road user error account slightly less than 20%. Human factors on, their own, account for 75 - 80% of accidents. Typical road and environment deficiencies are those, which provide misleading visual information, or insufficient or unclear information to the road users. Only occasionally accidents are caused solely by bad design. Human factors include excessive speed for the conditions, failing to give way, improperly overtaking or following too close and general misjudgements by both driver and pedestrian.

There are two basic types of road accident, which by definition have to involve a vehicle, are: personal injury and damage only.

A personal injury accident (PIA) is an accident involving an injury. The PIA refers to the accident as the event, and may involve several vehicle ands and several causalities (persons injured). The accident must occur in the public highway, including footways,

and become known to the police within 30 days of its occurrence. Causality is a person killed or injured in accident. Causalities are subdivided into killed (causality who dies within 30 days of accident but excluding confirmed suicides), seriously injured (an injury for which a person is detained in hospital as an in – patient), and slightly injured (an injury of minor character such as a sprain, bruise or cut). Drivers have legal obligations for reporting accident [19].

The police record only accidents, which are reported to them. On an average only 70% of accidents involving personal injuries are recorded by the police. Police are the primary source of information on road accident. Other sources include motor insurance companies and hospital causalities (accident and emergency) units. [Appendix B]

Some of the reasons for most nations, like Great Britain, success in reducing the number of fatal and seriously injured causalities are: [appendix C]

- Safer cars;
- Great compliance with seat – belt regulations;
- Safer roads – improved design and safety audit and use of road safety engineering measures;
- Reduction in drink/ driving;
- Changing attitudes with travellers more aware of the dangers of accident.

2.4 Highway Statistics: Presenting Accident Data For Analysis

Due to the fact that accident rates need to be developed in the context of this thesis, some literature review was performed. By extracting crash frequencies from the databases, one needs the denominator in order to develop crash rates (i.e. crashes per vehicle km travelled).

The highway statistics comprise a powerful tool for developing accident rates since they provide valuable measures in terms of highway mileage and the number of vehicle miles travelled. The Federal Highway Administration (FHWA) and the Office of Highway Management publish the highway statistics publication once a year.

Selected statistical tabulations are included in this publication, such as information on highway use and finance and the extent, characteristics and performance of the public highways, roads and streets in the Nation. Below are typical data analysis methods:

Regression to the mean: - accidents are rare event subject to random variation. This have a biasing effect if combined with the tendency to select the sites for treatment on the basis of accident records in the recent past. This effect is termed as ‘regression to the mean’. It is desirable to therefore to present data for analysis over a long period (at least 3 years).

Graphical: - presenting accident data on a map background provide an immediate identification of the location; that is, junctions and road sections where accidents have occurred – severity by location.

Stick Diagrams: - when a particular location is to be studied in more detail, it is useful to present the information as a stick diagram. The vehicle manoeuvres for each accident often has to be added manually using symbols. [Appendix D]

Histogram: - when studying a location to identify special accident features; like vehicle category, time of day, month of year, day of week, dry, wet, daylight or darkness, age of causality and type of causality.

Statistical Analysis

Significance level: the significance level for some accident statistic of x % implies that there is only a x % chance of that statistic occurring due to random fluctuations. We can refer to a significance level of x% or confidence level of (100 – x)% in the following terms:

Table .2.1 significance levels

Significance level (%)	Confidence level (%)	Significance
1	99	Highly significant
5	95	Significant
10	90	Fairly significant
>20	<80	Not significant

Poisson Test: useful to calculate the probability of a particular number of accidents occurring at a location in a given year when the long – term average number of accidents is known. For example if the average annual number of accident at a location is two and then in one year five accidents occurs, this can be shown using Poisson table to be significant. This is because the probability of five or more accidents occurring due to random fluctuations is only 5% and so there is a significance (95%) chance that a real increase in accident has occurred.

Chi – Square Test: this is a test for determining whether the number of accidents of a certain type at a particular site is significantly different to the number at similar (control) sites. It is also used for determining whether the number of accidents at a site after remedial measures has been carried out has changed significantly in reference to similar control site over the same period.

Table. 2.2 Chi – square variables

	Number of accident	
	Before measurement	After measurement
Treated site	b	a
Control site	B	A

$$X^2 = \frac{(bA - aB)^2}{(b + a)(B + A)(b + B)(a + A)} \quad \dots \dots \dots \quad 2.1$$

If $x > 4$, then the treated site is significantly different at the 5 % significant level.

Chi – squared (χ^2) test is also used to check whether there is a relationship between the selected parameters. The test is done in comparing the observed and expected values in two-way table, called contingency table [2].

$$\text{Expected value} = \frac{(\text{Row Total}) \times (\text{Column Total})}{\text{Overall Total}} \quad \dots \dots \dots \quad 2.2$$

$$x^2(\text{obs}) = \sum_{j=1}^c \frac{(O_j - E_j)^2}{E_j} \quad \dots \quad 2.3$$

Where, X^2 (Obs.) = calculated value of Chi – Square test

O j = observed data, actual data from the field (Police Report)

E j = Expected value, calculated as equation EE.

The value X^2 (Obs.) is then compared to the contingency table value, X critical, for the specified significance level.

- (D) Time Series Test: When data are arranged on the basis of their occurrence, they often form fluctuation from time to time. These fluctuations are caused by constantly working composite forces. There are;

 - a. The Secular Trend: This is irreversible movement in a time series, which continues in general, in the same direction over a long period of time.
 - b. Seasonal Variation: a short-term oscillation (movement) around the trend line. They are periodic movements, which occur regularly every year and have their origin in the nature of the year itself. Seasonally variable have two main causes, climate and custom.
 - c. Cyclical Variation: Refers to a long-term oscillation about the trend. The oscillation may vary in term, length and intensity but unlike the seasonal variation, we find cyclical components very rarely, since it takes more than 30 years to repeat itself. Cyclic variation is the most difficult to measure as they are mixed with irregular forces.
 - d. Irregular or random variation: changes not accounted for by trend, seasonality or cyclical effects. They occur because of random causes.

Estimation of seasonal variation

Seasonal variations are types of periodic movements, which occur within a year, most of the seasonal fluctuations are a reflection of underlining climatic condition or customs.

In this section it is will tried, to find best estimates and draw conclusions about the traffic accident that occur during the periods 1995 to 2005 in Addis Ababa. The most generally and frequently used methods for measuring the seasonal variations occurring with in a time series are.

- 1) Simple average method
- 2) Ratio –to - trend method
- 3) Link relative method
- 4) Ratio –to - moving average method.

Ratio to trend method is the most satisfactory method in which the data for each month are expressed as percentages of monthly trend values. And it is adapted in this thesis.

Steps to be followed.

- 1) Obtain the trend value by applying the method of least squares
- 2) Divide the original values of the series by the corresponding trend value and express the result as percentages.
- 3) Find the average of each month or quarter for all the years using either mean or median.
- 4) Adjust them if necessary by multiplying each index by k for monthly data.

$K=1200$ =sum of the indices for monthly data.

$K=400$ =sum of the indices for quarterly data.

The division of each monthly original value by the corresponding trend value produces seasonal indices, which may include cyclical and irregular variation. This may be an important disadvantage of this method [8].

2.5 Development of Accident Rates

Many researchers have attempted to find the variables most highly associated with crashes. Bernardo and Ivan studied the prediction of the number of crashes versus the crash rate using Poisson regression. This type of regression was used to model both the crash and crash rate. Small data sets for several intersections were used for this study.

Several ways of modelling highway safety were investigated, including different representations of traffic exposure and intersection effects as independent variables.

Poisson distribution allows for the relationship between exposure and crashes to be more accurately modelled as opposed to the linear relationship assumed in crash rate prediction. However, this study was only focused on intersections thus being site specific

In another study developed accident rates using the Highway Safety Information System database in order to use them for the development of the so-called Interactive Highway Safety Design Model (IHSDM). An accident prediction model was developed to produce average accident rates for different highway accident types. The objective of the study was to determine if the HSIS data could be used to develop the accident prediction model

Traffic accident rates are examined for relationship with volume-to-capacity ratios. Particular emphasis was given on the development of models to explain the differences between accident rates during weekends and weekdays, rear end accidents and fixed-object collisions and property damage only accidents versus accidents involving injury and fatality. It is concluded that the accident rates were highest in the very low hourly volume-to-capacity (v/c) range and decreased rapidly when the v/c ratio increased. Then the rates gradually increased as the v/c ratio continued to increase. This very important as in the following chapters it will be shown that this is consistent with the results obtained in this thesis [6].

The final outcome of this study is that the correlation between accident rates and the volume-to-capacity values followed a general U-shaped pattern. Regarding the property damage only accident rates, these had a general U-shaped relationship with v/c values. On the contrary the rates that involved injury and fatality decreased as the v/c ratio decreased.

2.6 Accident Prediction Model

Research on the subject of traffic flow modelling started some forty years ago, a model based on the analogy of vehicles in traffic flow and particles in a fluid. Since then, mathematical description of traffic flow has been a lively subject of research and debate for traffic engineers. This has resulted in a broad scope of models describing different

aspects of traffic flow operations, either by considering the time-space behaviour of individual drivers under the influence of vehicles in their proximity (microscopic models), the behaviour of drivers without explicitly distinguishing their time-space behaviour (mesoscopic models), or from the viewpoint of the collective vehicular flow (macroscopic models). Traffic flow models may be categorized according to various criteria (level of detail, operation) [5].

2.6.1 Traffic Flow Modelling And Simulation

Traffic operations on roadways can be improved by field research and field experiments of real-life traffic flow. However, apart from the scientific problem of reproducing such experiments, costs and safety play a role of dominant importance as well. Due to the complexity of the traffic flow system, analytical approaches may not provide the desired results. Therefore, traffic flow (simulation-) models designed to characterize the behavior of the complex traffic flow system have become an essential tool in traffic flow analysis and experimentation. The description of observed phenomena in traffic flow is however not self-evident. General mathematical models aimed at describing this behaviour using mathematical equations include the following approaches.

- Purely deductive approaches whereby known accurate physical laws are applied.
- Purely inductive approaches where available input/output data from real systems are used to fit generic mathematical structures (ARIMA models, polynomial approximations, neural networks).
- Intermediate approaches, whereby first basic mathematical model-structures are developed, after which a specific structure is fitted using real data.

Traffic models are also classified according to the following:

Scale of the independent variables (continuous, discrete, semi-discrete);

Level of detail (sub microscopic, microscopic, mesoscopic, macroscopic);

A microscopic simulation model describes both the space-time behaviour of the systems' entities (i.e. vehicles and drivers) as well as their interactions at a high level of detail (individually). For instance, for each vehicle in the stream a lane-change is described as a detailed chain of drivers' decisions.

Similar to microscopic simulation models, the sub microscopic simulation models describe the characteristics of individual vehicles in the traffic stream. However, apart from a detailed description of driving behaviour, also vehicle control behaviour (e.g. changing gears) in correspondence to prevailing surrounding conditions is modelled in detail. Moreover, the functioning of specific parts (sub-units) of the vehicle is described.

A mesoscopic model does not distinguish nor trace individual vehicles, but specifies the behaviour of individuals, for instance in probabilistic terms. To this end, traffic is represented by (small) groups of traffic entities, the activities and interactions of which are described at a low detail level. For instance, a lane-change manoeuvre might be represented for an individual vehicle as an instantaneous event, where the decision to perform a lane-change is based on e.g. relative lane densities, and speed differentials. Some mesoscopic models are derived in analogy to gas-kinetic theory. These so-called gas-kinetic models describe the dynamics of velocity distributions.

Macroscopic flow models describe traffic at a high level of aggregation as a flow without distinguishing its constituent parts. For instance, the traffic stream is represented in an aggregate manner using characteristics as flow-rate, density, and velocity. Individual vehicle manoeuvres, such as a lane change, are usually not explicitly represented. A macroscopic model may assume that the traffic stream is properly allocated to the roadway lanes, and employ an approximation to this end. Macroscopic flow models can be classified according the number of partial differential equations that frequently underlie the model on the one hand, and their order on the other hand.

Scale of the independent variables: -. Since almost all traffic models describe dynamical systems, a natural classification is the time-scale. We will distinguish two time scales, namely continuous and discrete. A continuous model describes how the traffic system's state changes continuously over time in response to continuous stimuli. Discrete models assume that state changes occur discontinuously over time at discrete time instants. Besides time, also other independent variables can be described by either continuous or discrete variables (e.g. position, velocity, desired velocity). Mixed models have also been proposed [6].

Representation of the processes: - In this respect, we will distinguish deterministic and stochastic models. The former models have no random variables implying that all actors in the model are defined by exact relationships. Stochastic models incorporate processes that include random variates. For instance, a car-following model can be formulated as either a deterministic or a stochastic relationship by defining the driver's reaction time as a constant or as a random variable respectively.

Operationalisation: - With respect to the operationalisation criterion, models can be operationalised either as analytical solutions of sets of equations, or as a simulation model.

Many researchers did intensive study on safety of main road junctions with the help of accident prediction models. The goal of this study was to estimate the expected value of the number of accidents using Poisson or negative binomial distributions were assumed. Also, several models were made for all injury accidents involving motor vehicles only, single accidents and rear-end accidents. Results of the study showed that the accident risk increased as the traffic share on the minor road increased. Ten accident categories were used in the study as shown in Table 2.1, below.

Table 2.3 Accident Category [3]

Accident Categories
Same Driving Direction (No turning Vehicles)
Same Driving Direction (One Turning Vehicle)
Opposite Driving Directions (meeting Accident)
Opposite Driving Directions (turning vehicle)
Intersecting Driving Directions (turning Vehicle)
Pedestrian Accident (on ped, Crossing)
Pedestrian Accident (away from ped, Crossing)
Off Road accident
Other Accident

Lack of good exposure data and the large quantity of data needed were the major disadvantages in completing this study. However, the accident prediction models provided reasonable results according to the past years data. A final conclusion was that the minor road at a T-intersection or a four-way intersection had a crucial effect on the safety of a junction due to the fact that the drivers approach the intersection at a higher speed, hence increasing the accident risk too.

2.7 Routing Algorithms:

The background presented in this chapter contributes to the complete understanding of the subject matter that is discussed in the rest of this thesis.

The Routing system will use an ant algorithm (Ant Based Control or ABC-algorithm). This algorithm uses some of the same principles that living ants in nature do. Although these ants only perceive a very small part of their environment, they can find their way back from the food to their nest. And these insects have a remarkable way of finding the shortest way between the food and the nest. They use a pheromone trail, which they can lay and sense. This is explained in further detail in the following section.

Implementations of these principles have shown to be very promising. The algorithm is especially suited for the proposed distributed approach of the Routing system. Conventional algorithms for finding shortest paths, like Dijkstra's algorithm are designed for non-distributed networks.

Here we will discuss the two routing algorithms, although ABC – algorithm is used in the project. Dijkstra's algorithm is a centralized routing algorithm for a static environment with guaranteed shortest paths. A centralized router assumes that all data is available at one location. The ABC algorithm is a decentralized routing algorithm for a dynamic environment with no guarantee for absolute shortest path. A decentralized router can compute route even if the data is distributed over several locations.

2.7.1 Dijkstra's algorithm

Finding the shortest path is a very common problem. E.W. Dijkstra made a great contribution to solving this problem with a path finding algorithm. This algorithm is carefully described in. Dijkstra's algorithm solves the single-source shortest paths problem on a weighted, directed graph G , with vertices V (nodes) and edges E (links). It assumes that all weights (or travel times) are nonnegative and static. The algorithm finds the shortest paths from one source in a graph to all destinations. Of course the shortest paths from all sources to all destinations can be found by repeating the execution of the algorithm for all sources. Calculating the shortest path is by using the Dijkstra's Algorithm. Weight of each line is shown in every hour for each direction. The program will calculate the travelling time in each section by:

- Checking the arrival time of the starting of that section,
- Checking the turntable waiting time.
- Find the travelling speed from the table according to the starting time.
- Calculate the travelling time for that section.
- Compare the arrival time of the destination node with the previous arrival time.
Select the shortest time.
- Recalculate the whole network until complete.
- Output is shown in the Vb Objects.

2.7.2 Distributed Routing System: Ant Based Control (ABC)

The neurones in our brains are only capable of stimulating or inhibiting other neurones when they are stimulated themselves. Still our brains, which are composed of neurons, enable people and other animals to do amazing complex things. The same idea goes for a lot of natural living systems.

Complex characteristics emerge from the interactions between relatively simple units and their environment. This behaviour is most often called emergent behaviour. Ants show this behaviour as well. A group of ants does not have a central controlling authority that tells them what to do. They have only local knowledge because of their interaction with

the environment. They simply change direction for instance when they find a large obstacle in their way. But they also communicate indirectly with each other through the environment, which is called stigmergy. Many other social insects also use stigmergy. One of the emerging abilities of a group of ants that use stigmergy is to find the shortest route from their nest to a food source [19].

Ants only react to local stimuli from the environment but they can also change those local stimuli. Such a modification will influence future actions of other ants at that location.

There are two types of modifications. The first type is called sematectonic. Modifications of this type change physical features. An ant digging a hole is an example of this. Ants following the first ant perceive a changed environment, which can cause them to expand the hole. The cumulative effect of such small changes can result in complex structures. The environment can also be changed without contributing to the goal directly. This is called sign-based stigmergy. The goal of sign-based stigmergy is to influence subsequent behaviour. Ants are very good in using this second method of changing the environment. They lay a special sort of volatile hormone, or pheromone, to create a signalling system between ants.

Laying and sensing pheromones

Ants use the laying of pheromone to find the shortest path from their nest to a food source and vice versa. Consider the following situation (Figure 2.2) where two ants are looking for food. They can reach an apple via two alternative routes. The southern route is shorter than the northern route. The first ants that have to choose a direction have no knowledge about the shortest route, so they choose randomly. One ant takes the northern route; the other uses the southern route (see Figure 2.3). On their way they lay a pheromone trail, which diffuses slowly. The ant taking the shorter route reaches the food quicker and returns earlier to the nest. This is shown in figure 2.4. Here you also see a third ant looking for food. This ant will sense the pheromone and prefer the route with the stronger pheromone trail.

The southern route will have a stronger pheromone trail because one of the ants already passed twice, while the other route is only passed once. Consequently the ants will more

often use the shorter paths. Some ants will however use other routes sometimes, because there is still pheromone and because they make errors. This ensures them to check other routes, which may be shorter in the future because of a changed environment.

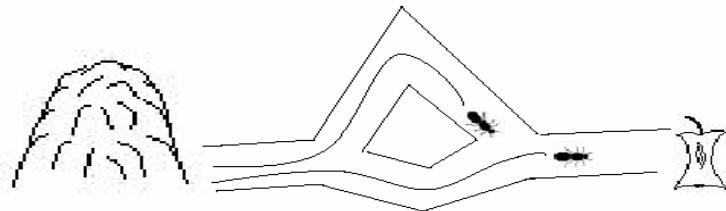


Fig. 2.2 Ant choosing a random route

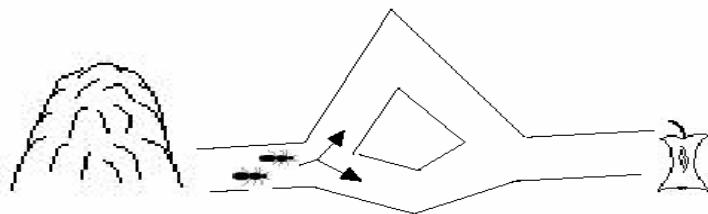


Fig. 2.3 The ants laying pheromone trail

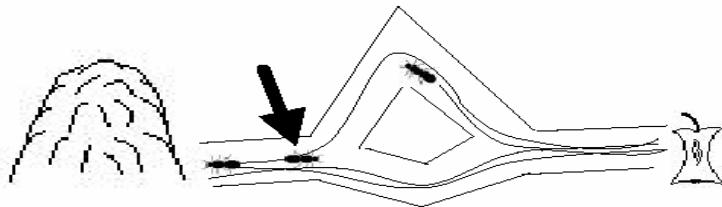


Fig. 2.4 A third ant chooses biased

Reasons for choosing the shortest path

There are mainly three reasons why the pheromone on shorter paths is stronger and the ants choose biased for shorter paths:

- *Earlier pheromone:*

Shorter route will be completed earlier. So the first pheromone trails will attract ants to follow shorter routes.

- *More pheromone:*

The ant density will be higher on shorter routes, causing a merged pheromone trail of more ants.

Even if an equal number of ants are taking one of two alternatives, the shorter alternative will have a higher ant density and thus a stronger pheromone trail.

- *Younger pheromone:*

When an ant finishes a shorter route the pheromone is still younger. So it is less diffused and stronger, attracting more new ants.

Ant Based Control algorithm

The idea of emergent behaviour of natural ants can be used to build routing tables in any network. Others have already applied this idea to routing in communication networks.

Mobile agents - motorists agents move across the network between randomly chosen pairs of nodes. As they move, pheromone is deposited as a function of the time of their journey. That time is influenced by the congestion encountered on their journey. Instead of real pheromone a probability is used for all the alternatives. A high probability represents a lot of pheromone. The sum of the probabilities for all alternatives (from one node to one destination) is one. For every possible destination separate probabilities are used. This could be compared to the existence of different kinds of pheromone for different food sources. The agents select their path at each intermediate node according to the probability for each alternative next node. The probability of the agents choosing a certain next node is the same as the probability in the table.

The probability tables only contain local information. Each time an agent visits a node the next step in the route is determined. This process is repeated until the agent reaches its destination. Thus, the entire route from a source node to a destination node is not determined beforehand. Agents are launched at each node with regular time intervals with a random destination node. They travel around the network using the probabilities in the probability tables. The probabilities per destination are all filled with equal values for all nodes before the process begins. So initially the ants will walk randomly. When an agent finds his destination he will go back to its source via the same way it came from.

On its way back it changes the probabilities for the destination it just came from. Short paths get a big update and longer paths receive less update. This way the probabilities for shorter paths will increase faster. When the probability for one alternative is incremented

the probabilities for the other alternatives are decremented. This should keep the sum to one. This process produces probability tables, from which the shortest routes to any destination can be read [19].

Figure 2.5 is a simple network with 7 nodes. A possible probability table of node 2 is shown in Table 2.1. There is an entry for every possible destination and every neighbouring node. When traffic needs to be routed the highest probability in the row with the desired destination is taken. The next node corresponding to this probability is used to route the traffic. For example traffic in node 2 with destination 6 will be routed via node 5, because this node has the highest probability for this destination.

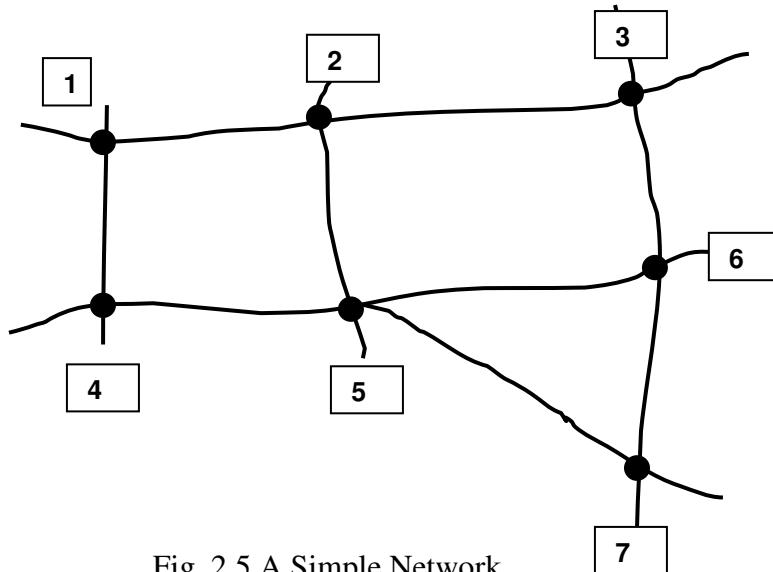


Fig. 2.5 A Simple Network

Table 2.4-probability table of node 2

(2) Destination	Next	1	3	5
1		0.90	0.02	0.08
3		0.03	0.90	0.37
4		0.44	0.19	0.37
5		0.08	0.05	0.87
6		0.06	0.30	0.64
7		0.05	0.25	0.70

The probabilities 0.06, 0.30 and 0.64 indicate the possibility of getting to the destination node 6, starting from node 2, through node 1, node 3 and node 5. Thus, routing through node 5 and to node 6 has the highest possible alternative. As the traffic system changes though time, these probabilities also varied.

The use of the ABC-algorithm allows the Routing system to be distributed. This means that the computation is done on several computer systems that are mutually connected via a network. Distribution of computational power gives some advantages above a central routing system. Firstly what normally has to be done by one computer system is now done by several computer systems, which increases the speed and the memory space. Secondly, when properly implemented the failure of one of the systems does not have to imply a total break down of the Routing system. This does however involve some extra communication necessary for information that is not available on the concerning computer system. It will eventually depend on the amount of information that needs to be communicated between the computer systems whether the actual speed will be higher than with a central routing system. The results of this thesis will have to show that the ABC-algorithm is sufficiently accurate to route the traffic.

2.8 Global Design

In this section it will be explained about the structure of the system from the viewpoint of the vehicle and its driver. A vehicle is driving through a city and its driver wants to be informed how to get from A to B in the shortest time. The driver enters the address where he wants to go and expects a routing system to tell him where to go. Besides the destination the Routing system needs to know the location where the vehicle is at the moment. Therefore the vehicle picks up signals from GPS-satellites (Global Positioning System). This is shown by arrow in Figure 2.4. GPS is a system for determining a position with an accuracy of a few meters. This position is measured in latitude/longitude coordinates.

In the vehicle these coordinates are translated in a position on a certain road with the aid of a digital map of the city. Now the vehicle has enough information to request the Routing system what route to follow. The vehicle sends its position and its desired destination along with the request for the route to the Routing system (arrow C). Arrow D is the answer from the Routing system that contains the route that the vehicle should follow. These steps are pretty obvious, but we have skipped arrow B. This arrow indicates that the vehicle provides the Routing system with information about the route it has followed since the previous time.

2.8.1 Dynamic Data

To route the traffic dynamically through a city we need dynamic data about the state of the traffic in the city. This can for example be directly from sensors in the road-surface. Such sensors can count vehicles and measure the speed of the vehicles. That information can be used to compute the time it takes to cover a part of the road. Another source can be the traffic information services. They can inform the system about congestion, diversions of the road, roadblocks and perhaps open bridges. And finally the vehicles themselves can provide the system with information about the path they followed and the time it took them to cover it.

The current technology enables to fix the position of a vehicle with an accuracy of a few meters. That position can be communicated to the system along with the covered route. For our routing system we will at first only use the latter type of information as dynamic data. But of course the model is open for additional types of dynamic data. The information from the vehicles is handled by a separate part of the routing system, called the timetable updating system (figure 1). This subsystem takes care that the information is processed for use by the ant-based algorithm. This way one vehicle drives a certain route and sends its performance to the routing system. Another vehicle is able to use that information to choose the shortest route.

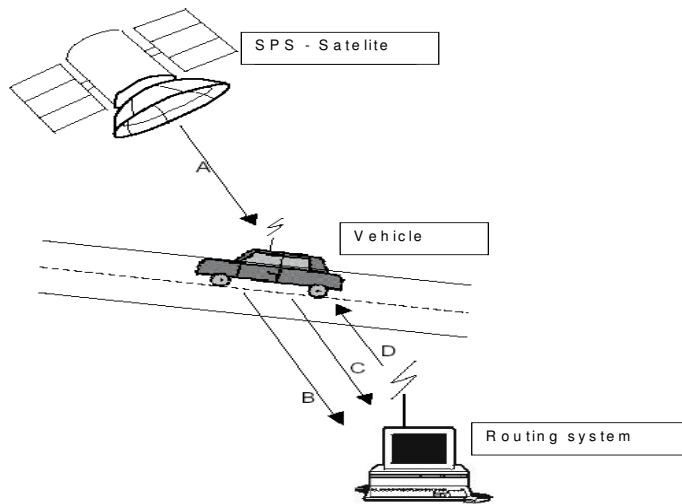


Fig. 2.6 Communication of Vehicle

Table 2.5 Communicated data between the different objects

	From	To	Data
Arrow A	GPS – Satellite	Vehicle	Send – position, Latitude/ longitude Co – ordinates
Arrow B	Vehicle	Routing System	Update, Previous time/ position
Arrow C	Vehicle	Routing System	Request – Route, Current position, destination
Arrow D	Routing System	Vehicle	Answer – Route, Road A, Road

2.9 An overview of Transport / Traffic Study Process

At some stage(s) in the planning of a road or road system it will be necessary to carry out the traffic studies to estimate the volume(s) of traffic that will have to be considered in a design year. Traffic data also required for economic and environmental assessment in relation to the justification, scale and location of scheme alternatives. Traffic volume for some future design year (in Britain the design year is 15 years after the opening of the road/ road improvement) is delivered from measurement of current traffic and estimate future traffic. Figure 2, 7 below indicates the basic constituent of design volume for an individual road. . By current traffic is meant the number of vehicles that would use the new road if it were open to traffic at the current measurement is taken. Current traffic is composed of reassigned traffic and redistributed traffic. Reassigned traffic is the amount of existing same destination traffic that will immediately transfer from the existing road that the new road is designed to relieve. Redistributed traffic is that which already exist on

other roads in the region but which will transfer to the new road because of changes in the trip destination brought about by the new road's attractiveness [1].

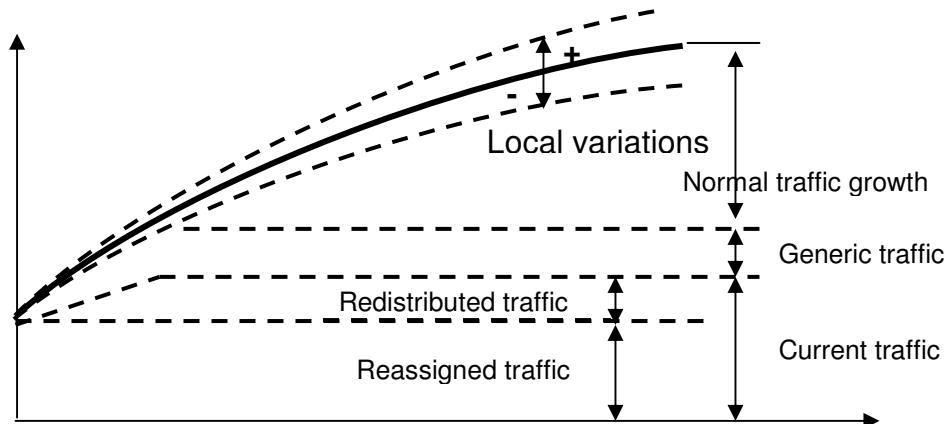


Fig. 2.7 Constituents of road design traffic volume

Normal Traffic growth is the increase in traffic volume due to the cumulative annual increase in the number and usage of motor vehicle. Generated traffic is mean the future vehicle trips that are generated a new as a direct result of the new road. Generated traffic is generally considered to have three constituents components: induced, converted and development traffic. Induced traffic consist of traffic that did not exist previously in any form and which result from the construction of a new facility, and of traffic composed of extra journey by existing vehicle as a result of increased convenience and reduced travel time via the new road. Converted traffic is that which result from change in mode of travel. Development traffic is the future traffic volume component that is due to developments on land adjacent new road [2].

2.10 Traffic Surveys

The main reason for understanding the traffic flow is to provide an objective measure of an existing situation. A survey will provide a measure of conditions at the time that the survey was undertaken. Traffic flow varies by time of day, day of the week and month of the year. Morning and Evening peaks as people travel to and from work. Traffic flow tends to vary by day of the week.

2.10.1 Traffic Counts

There are a number of survey methodologies available to help to understand the traffic movement. The main techniques are described in this section, with their principal applications. All traffic count methodologies described are non – intervention, that is they do not affect the traffic flow being measured.

2.10.1.1 Automatic Traffic Count

Automatic traffic counts are used to mechanically measure the traffic volume moving past the survey point. The counters normally use a pressure tube or an inductive loop, which is fixed across the road at the census period. The pressure tube is compressed each time a vehicle axle crosses it. This sends a pulse along the tube, which is counted, and hence the vehicular flow can be estimated. More modern system can use piezoelectric tube and the electrical pulses are counted [2].

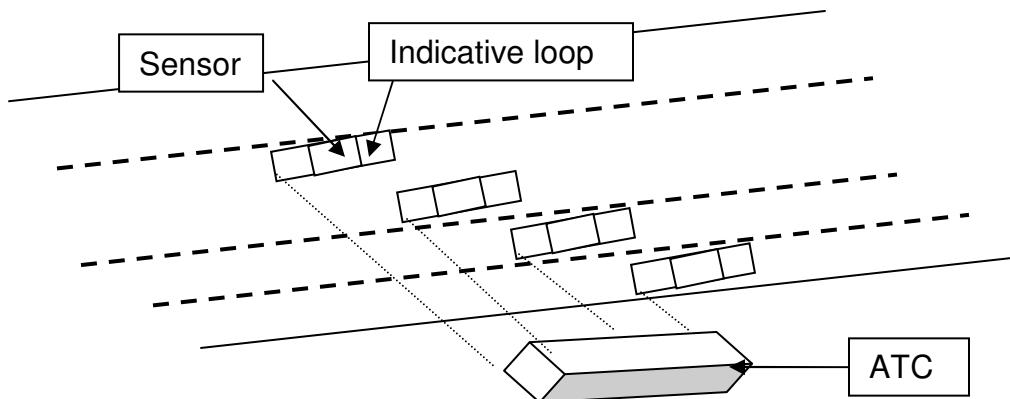


Fig .2.8 typical automatic traffic counter installation

2.10.1.2 Manual Counts

Traffic flow can be measured by manual observation, instead of using an automatic counter. Traffic flowing past a survey point is counted by an observer, who would record the flow using either, a tally counter. A manually – classified count (MCC) records directional traffic flow past a point survey point. The survey point could mid – link or at a junction.

2.11 Area – Wide Surveys

The surveys described above are adequate for measuring traffic flow and direction of movement at a single point, or at a single junction. However, if we wish to understand the movement over a wide area, other methods have to be used. Three techniques are described below:

1. Number Plate Surveys: - to now how the traffic is circulating in a limited area. The technique used is to record the registration mark of each vehicle as it enters and leaves the system being studied and to then match the registration marks, to establish how a vehicle travels through the road system being studied.
2. Origin and Destination (O & D) Surveys: - the alternative way to establish where the drivers are travelling is to ask them, using an O & D Survey. The standard techniques are roadside interview and survey and self – completion questionnaires.
3. Roadside interview surveys: - a sample of drivers is stopped at the side of the road and asked their O and D, plus any other data, which could be of relevance. Once the driver has been selected for the interview and stopped in the interview bay, he should be asked to provide the necessary answer, not more than 2 minutes, and then released as soon as possible. Although a driver must stop by the police officer, there is no obligation on the driver to participate with the interview
3. Self-completion form: - in some locations, it is not possible to safely slow down and stop traffic. In these circumstances the reply paid questionnaire may offer a suitable alternative methodology, to provide the information required [1]

2.11.1 Speed Survey

There are two simple techniques to measure the speed of traffic. The first method uses speed-measuring equipment, such as radar gun, to record the speed of the traffic, or a sample of traffic passing a particular point in space based on Doppler effect of the change in frequency of the microwave beam reflected by the vehicle.

The time mean speed, the average speed of a vehicle passing a given point over a specified period is defined as:

$$V = \sum_t (V_t / n).$$

Where, V is the time mean speed

V_t the speed of an individual vehicle

n is the number of vehicle observed.

Data required can be collected using a speed measurement equipment device such as a radar gun

The second measurement of speed is space mean speed. This is a measure of the speed of travel over a measured distance, rather than a single location. Thus if an observer wish to know the speed of vehicle travelling along a length of road L, then each vehicle i takes time t_i to travel the link then space mean speed is defined as:

$$V = \frac{1}{\sum_i (t_i/n)} \quad \dots \quad 2.4$$

Where, V is the Space mean speed

t_i the travel time of the i^{th} vehicle

n is the number of vehicle observed.

2.11.2 Video Surveys

The use of video as a data collection tool in traffic engineering is the relatively new but potentially very powerful concept. A strategically placed camera can be used to observe traffic and the parking activity in a street and, depending on location and equipment, it is possible to survey up to 400 meters of road from a single vantage point. Cameras are mounted high to minimize the obstruction of the longer view from vehicle near to the camera. One of the key advantages of camera is that it records every thing that happens. With the video survey, it is possible to review the video and observe other activities, which were brought to be an important when the survey was planned.

The video has a particular advantage when flow are very high and it is difficult to count manually or when we wish to study a particular location where there are no absolutely sure what the key issue is. With the video we can simultaneously record: Traffic flow, turning measurements, Speed, congestion and delay, Parking and loading and pedestrian movement.

2.12 Capacity Analysis

Capacity Definition: Capacity of a facility defined as the maximum hourly rate at which a person or vehicle can reasonably be expected to travel a point or uniform section of a lane or roadway during a given time period under prevailing roadway, traffic and control conditions.

The term capacity when referring to a roadway, link or junction is its ability to carry, accommodate or handle traffic flow. Traditionally capacity has been expressed in number of vehicles or passenger cars units (PCU). (Vehicles vary in their performance and the amount of road space they occupy. The basic unit is the passenger car and other vehicles are counted as their PCU equivalent, e.g. a bus might be 3PCUs and a pedal cycle 0.1PCU.) There is no absolute capacity value that can be applied to a given road way link or junction. Maximum traffic handling capacity of a road depends upon many factors [2].

- Road layout including width, vertical and horizontal alignment, the frontage land use, frequency of junctions and accesses and pedestrian crossings.
- Quality of road surface, clarity of road making, signing and maintenance.
- Proportion of each vehicle type in the traffic flow and their general level of design, performance and maintenance.
- The number and speed of vehicles and the number of other road user, such as cyclist and pedestrian.
- Ambient condition including time of the day, weather and visibility.
- Road user levels of training and competence.

2.12.1 Effect Of Width On Capacity

The capacity of traffic lane is, with in limits, proportional to its width. Clearly, there is lower limit to the width of a lane below which it is operationally impractical to run the vehicle. Below a lane width about 2.0 meters capacity deteriorates rapidly. As lane width approaches the point where two narrow lanes can be marked or vehicles tend to form up two lanes there is a rapid increase in the capacity [1].

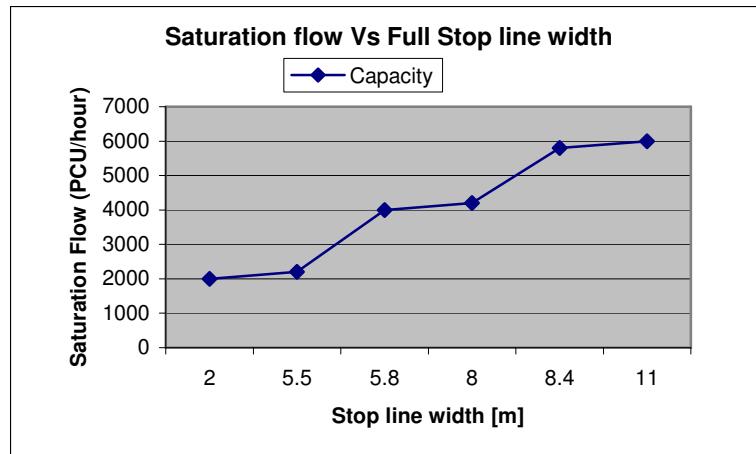


Fig. 2.9. Simplified relation between lane width and saturation flow.[1]

2.12.2 Flow - capacity Relationship

A measure of performance of a highway or a junction is the ratio of demand to capacity (RFC) or traffic intensity. As the RFC approaches 1.0 the level of congestion and queuing will be increased. There are two basic options on the effect of traffic intensity on queue length: the steady state theory suggests that a traffic intensity approach 1.0, queue length will approach infinity; and the deterministic theory assumes that no queuing occurs until the RFC exceeds 1.0.

In practice it can be easily observed that queuing starts to occur well before an RFC of 1.0 is reached and it is equally clear that queuing length does not approach infinity at this point [2].

$$\text{Density (D)} = \frac{\text{Average number of vehicle in a length of highway (L)}}{L} \quad \dots \quad 2.5$$

When the density is zero flow is also zero; when the density increased to a maximum there is no flow. Maximum flow occurs at some point between these values.

$$\text{Capacity} = \frac{100V}{S} \quad \dots \quad 2.6$$

Where, C = Capacity in vehicle per hour per lane, V = Speed in K.P.H

S = Average spacing in meter of moving vehicles.

The value of headway distance, S, could be determined from the following formula as;

$$S = L + \frac{1000tV}{3600} + \frac{1000V^2}{3600} \times \frac{1}{2gf} = L + 0.278tV + \frac{V^2}{254f} \quad \dots \dots \dots \quad 2.7$$

Where. L = length of vehicle [m], t = perception reaction time [s], f = friction factor

g = gravitational acceleration [m/s^2]

Greenshields, who used time lapsed photographic technique derive s as;

$$S = 21 + 1.1 V \quad \dots \dots \dots \quad 2.8$$

S = spacing in feet; v = Speed in MPH

The road research laboratory, U. K. found the following formula as;

$$S = 17.5 + 0.8 V + 0.004 V^2 \quad \dots \dots \dots \quad 2.9$$

S = spacing in feet; v = Speed in feet/sec.

2.13 Traffic Signs and Markings

An important part of any road is the means by which the traffic engineering conveys information about the road and any regulations that affect the way it is used to users. If this is done successfully it makes to travel both safer and more efficient and it help the road users to insure that they comply with the regulation governing the road that they are using.

Traffic signs and markings divide logically in to a number of broad types or categories.

These are:

- Warning sign: provides advance warning of some feature,

In the form of red triangle with the point uppermost and warn of features on the highway. The centre of the triangle is white with graphics in black representing the hazard being warned about.

- Regulatory sign: announce and establish traffic regulation.

Most of these signs are shown on circular sign with a red border and a white centre showing the regulation or prohibition.

- **Informatory sign:** gives the road user information about features and factor, which may be of assistance to them in making their journey.
Rectangular blue signs with a white edge and includes the sign such as the sign showing that the road is a cut – de – sac, etc. advanced warning signs carry the appropriate triangle warning sign with in the blue sign.
- **Direction sign:** sign post showing the route to be followed to reach a given destination.
Positioning of the signs relative to a junction so that the driver gets suitable sight lines and time to read the sign before having to make navigational decision and manoeuvring.
- **Road markings:** cross all groups and can inter alia show the position those vehicles should adopt on the road, hazards [1].

2.14 Traffic Management and Control

Traffic management arose from the need to maximize the capacity of existing roadway networks with in finite budget and, therefore, with a minimum of new construction. Methods, which may be seen as a quick fix, require innovative solution and new technical developments. Introduction of signal - controlled pedestrian crossing not only improved the safety of pedestrians on busy road but improved the traffic capacity of road by not allowing pedestrians to demonstrate the crossing point.

2.14.1 Demand Management

As the traffic demand and congestion increased, drivers found alternative route. Route safety was compromised as drivers travel at high speed to maximize the benefit of diverting from their normal route. In most countries the daily traffic flow profile is similar. Figure below shows the general pattern.

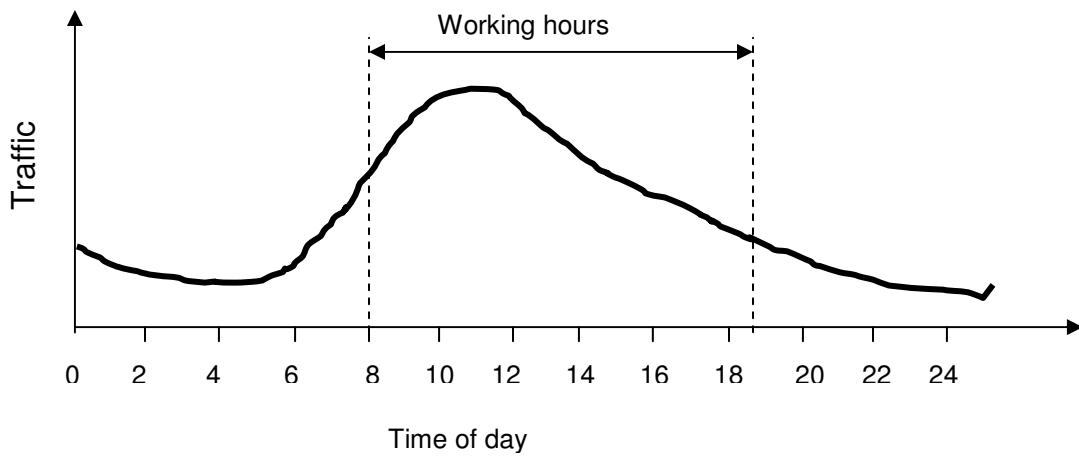


Fig.2.10 Typical daily flow profile in a city.

The figure above shows that peak periods are relatively short and that for long period of time the day the traffic flow are below the road's capacity. As delays increase, drivers realized that there is a spare capacity at other hours to arrive at and depart from their places of work before and after the peaks. The effect of this is that the peaks last for longer and is known as peak spreading. Daily flows profile as in fig. 2.11, shows that the majority of daytime capacity has been utilized, where the traffic flow is normalized to less value [2].

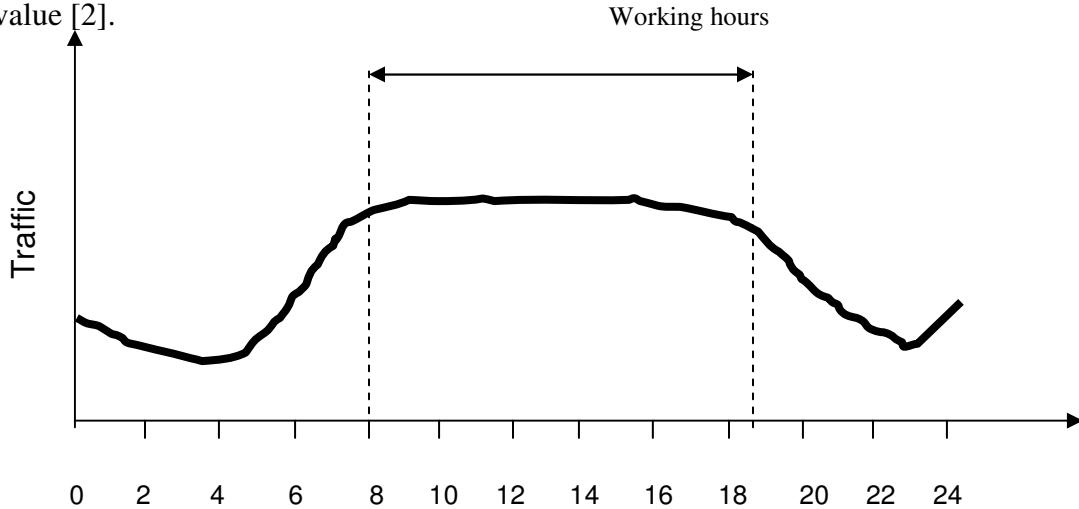


Fig.2.11 Daily profile showing capacity fully utilized during the working

2.14.2 Junction Type

The majority of capacity problems occur at the road junction. Due to the various conflicting demands it is not surprising that two third of traffic accidents occur at road junction. There are many varying junction types, in detail, but they can be broken in to five basic types.[Appendix E]

1. Un – controlled non – priority junctions
2. Priority junctions
3. Roundabout
4. Traffic signal
5. Grade separation.

Vehicle speeds are affected by many factors including speed limit, horizontal and vertical alignment, visibility, and highway cross sections, spacing of junctions, accesses, pedestrian crossings and maintenance standards [2].

2.14.3 Visibility

To enable drivers to safely crossing or enter the major road traffic stream, they must be able to see and to judge their approach speeds and available gaps in the major road traffic. Visibility splays are provided from the side road to left and right. A triangular sight line envelope, measured along the centreline of the side of road and along the major road kerbline must maintain clear of obstruction above the drivers eye – height of 1.05m.

The visibility envelop is defined by its x and y distances.

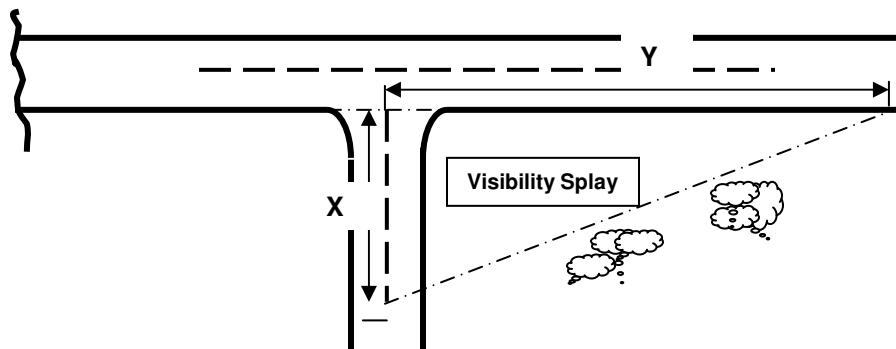


Fig. 2.12 Visibility requirements at a priority junction

The x distance should be a maximum of 15m and minimum of 9m at junctions on major roads. The x distance can be reduced to 4.5m where flows are low and an absolute minimum of 2.5m. The y distance is dependent up on the major road design speed and its distance should not be compromised. The visibility splay joins the two points defined by x and y except on a curved alignment where it should be tangent to the carriageway edge.

Table. 2.3 - distance relation to design speed.

Designed speed of major road (Km/hr)	100	85	70	60	50
y - Distance (m)	215	160	120	90	70

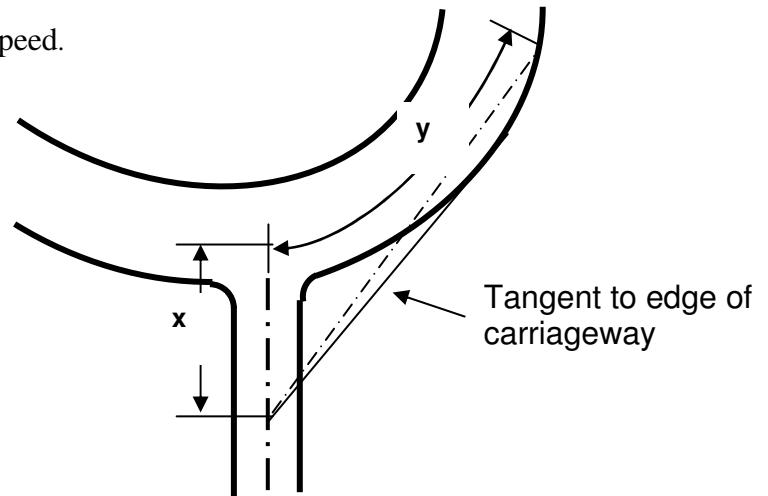


Fig. 2.13 Visibility requirement at a priority junction on a curved major road

Generally, the visibility splay should be within the major roadway boundary to insure that it can be maintained free of obstruction, where also in major roads the central reservation or ‘ghost island’ for vehicle to wait is provided [3].

2.14.4 Accident Influencing Factors

The main purpose of transportation system is to provide the efficient and safe movement of freight and passenger from one place to another. The economic development is directly and strongly related to the availability of transportation. The soaring number of vehicles on the road had created a major social problem through traffic accidents due to the loss of lives and material. Moreover, in Addis Ababa traffic accidents rates are still quite high. Therefore, the issue of road safety is a major concern. The most effective way to reduce road accident is to better understand the causative road accidents hence to prevent the occurrence of road accidents.

Considerable past studies were emphasized on identification of black spot, with the participation of Addis Ababa Traffic Police Bureau and Federal Road Transport Authority. Accidents are rarely caused because of one single factor. Thus, a multi-disciplinary approach is essentially needed in understanding the problems and providing better and appropriate solutions.

2.14.5 EAN (equivalent accident number) and AR (accident rate) calculations

EAN (Equivalent Accident Number) and AR (Accident Rates) are normally considered better measures of risk than accident frequencies alone, since they account for different traffic flow. The standard equation for calculating EAN is [3];

EAN = 12 Death + 3 Seriously Injured + 3 Lightly Injured + 1 Material Losses 2.10

Table 2.4 Values for Accident Type

Accident type	Value
Death	12
Serious Injured	3
Light injured	3
Material Losses	1

The standard equation for calculating AR is:

$$AR = \frac{(AF \times 10^8)(100 \text{ MVK})}{L \times n \times ADT \times 365} \quad 2.11$$

Where AR = Accident Rate

AF = Accident Frequency

ADT = Average Daily Traffic (pcu/hour/2 lanes)

L = Road Section Length (km)

MVK = Accident per million Vehicle – Kilometers of travel

n = Number of accident years

2.14.6 Saturation Flow Analysis

Freeway capacity as "the maximum sustained 15-min flow rate that can be accommodated by a uniform freeway segment under prevailing traffic and roadway conditions in one direction of flow. [Highway Capacity Manual].

"Capacity" is typically measured in terms of passenger cars (pc) per hour (ph) per lane (pl) and varies with free flow speed (FFS), measured in km/h. FFS is "the mean speed of passenger cars measured during low to moderate flows." When measured in the field, FFS is best determined by observing the speeds of passenger cars during weekday off-peak hours. The passenger-car flow rate, v_p (pcphpl), can then be estimated by:

$$3100 - 15 \text{ FFS} < v_p \leq 1800 + 5 \text{ FFS} \quad \dots \quad 2.12$$

The upper bound approximates the freeway capacity and occurs at times of lowest level of service. From the flow rate, the average passenger-car speed, S (km/h), can be estimated by [3].

$$FFS = \left[\frac{1}{28} (23 \text{ FFS} - 1800) \left(\frac{V_p + 15 \text{ FFS} - 3100}{20 \text{ FFS} - 1300} \right)^{2.6} \right] \quad \dots \quad 2.13$$

2.15 Probability distribution functions

2.15.1 Gamma distribution

Unlike to exponential distribution has only one parameter; the gamma distribution has two parameters. The gamma distribution is defined using the two parameters β and α , which can be used to generate a large variety of forms of probability density functions. The probability density function for the gamma distribution is:

$$f(x) = \begin{cases} \frac{\alpha^{\beta}}{\Gamma(\beta)} x^{\beta-1} e^{-\alpha x}, & x > 0 \\ 0 & \text{otherwise} \end{cases} \quad 2.14$$

Where, the gamma function is approximated by $\Gamma(\beta) = (\beta-1)!$

The gamma function can be seen as a general form of the factorial operator that applies to all positive numbers, not only to whole numbers. Parameter β is called the form parameter and $\theta = (1/\alpha)$ the scale parameter [3].

2.15.2 The Erlang distribution

The probability density function of the gamma distribution is often referred to as the Erlang distribution of the order k if $\beta = k$ is an integer. Erlang was a Danish telephone engineer, who was one of the first developers of the waiting time theory.

$$f(x) = \begin{cases} 1 - \sum_{i=0}^{k-1} \frac{\left(\frac{kx}{\bar{x}}\right)^i! e^{\left(\frac{-kx}{\bar{x}}\right)}}{i!}, & x > 0 \\ 0 & x \leq 0 \end{cases} \quad 2.15$$

Chapter 3

3 Methodology

This chapter will cover different aspects of methodology used during the research. It will present the different options available to carryout the study and gives reasons why a particular method was selected at different stages of the project. As a lot of data collection is involved in the project, the way the collection was made can affect the outcome of the project. For this reason, the data collection method selected on the course of the project will also be discussed here. Each paragraph will detail the motivation for the methodology choice made for the study. The chapter will end by summarizing the overall research plan and details of the path taken in the study.

3.1 Research approach

Research is an active, diligent and systematic process of inquiry in order to discover, interpret or revise facts, events, behaviours, or theories, or to make practical applications with the help of such facts, laws or theories. The scope of the research process is to produce some new knowledge [20].

This, in principle, can take three main forms:

1. Explanatory research: testing hypotheses and theories that explain how and why a phenomenon operates as it does.
2. Constructive research: a new solution to a problem can be developed.
3. Empirical research: empirical evidence on the feasibility of an existing solution to a problem can be provided.

In this particular study, the purpose is to solve a problem in Road Traffic based on the route management concepts. The data collected from the Addis Ababa Traffic Police Central Office will be used to justify the proposed solution. Therefore, this study can be categorized partly as an empirical research and as Constructive research, since it is tried to show the link between the traffic accident and route selections at pick hours.

Empirical research methods are a class of research methods in which empirical observations or data are collected in order to answer particular research questions. While primarily used in academic research, they can also be useful in industrial researches.

Empirical research normally starts with some previously set theory, which the researcher develops to explain and/or predict what happens in the real world. The purpose of the research is to test the theory and possibly refine it. Initially a research question is formulated. To be empirically tested, the research question will need to be transformed into a theoretical model, consisting of theoretical constructs causal relationships and observed variables.

The theoretical model is generally developed based on analysis of the literature. The theoretical model forms the basis both for collecting and analysing data, and may be modified as a result of the research. The first attempt made during the research was to have the overall picture of the research area. It is our daily news that traffic accident is increasing in Addis Ababa. The researcher job demands his to be on the road for more than half of the office hours. This helps him to recognise the actual traffic accidents and associated causes.

There is also a separate section in the researchers organisation, which updates and teaches the employees on defensive driving and road safety. Since safe driving on the road is not the responsibility of a single individual action and the researcher being part of it, the research attention comes in to picture.

Therefore the research is intended to answer the following questions;

- What are the main causes for the increase in the number of road traffic accident in Addis Ababa?
- Who are the main players in the accidents?
- What are the estimated amount of property damage and the share of insurances to cover claims?
- Is there time serious relationship of the road accident?
- Is there a possibility to decrease road traffic accident by the method of route management?
- What suggestion can be given to the respective responsible authorities from the study?
- What recommendations can be drawn from the study?

To attempt those research questions, the following steps will be carried out during the phase of the

- Literature survey
- Close observation road traffic flows
- Pointing out and Identification the possible potential incidents
- Statistical Data analysis from the police records
- Software program for route selection based on traffic density and risk
- Field trial on route selection and Present the finding for further examination of the outcome
- Recognize how different groups benefit from the study

3.2 Research Method

The method used when collecting, processing and analysing the gathered information can be either quantitative or qualitative research method.

Quantitative research methods: collect numerical data (data in the form of numbers) and analyse it using statistical methods.

Qualitative research methods: collect qualitative data (data in the form of text, images, sounds) drawn from observations, interviews and documentary evidence, and analyse it using qualitative data analysis method [10].

Qualitative methods tend to be more appropriate in the early stages of research and for theory building. Quantitative methods tend to be more appropriate when theory is well developed, and for purposes of theory testing and refinement. In practice, no research method is entirely qualitative or quantitative. For example, a survey may collect qualitative as well as quantitative data using open-ended questions; an experiment may include observations of participant behaviour as well as measures of response time and accuracy; a case study may incorporate quantitative data (e.g. system usage statistics) as well as qualitative data (e.g. interviews with users).

The selection of an appropriate research method is critical to the success of any research project, and must be driven by the research question and the state of knowledge the most common quantitative methods are:

- Experiment: apply a treatment, measure results (before and/or after): this is the only method that can demonstrate causal relationships between variables.
- Survey: ask questions (face to face interview, telephone, mail, internet)
- Historical data: look for patterns in historical data.

The most common qualitative methods are:

- Case study: observations carried out in a real world setting. The objective is to immerse oneself in the situation and gain a realistic understanding of the phenomena in its natural setting.

- Action Research: apply a research idea in practice, evaluate results, and modify idea. It is more of a combination of an experiment and case study.

The nature of the study requires both quantitative and qualitative information to reach a good understanding of road traffic accident causes and trends and to make good measurements. Both kinds of methods have also been used to support conclusions made in the thesis. Mixing qualitative and quantitative research methods is called triangulation method. While most researchers develop expertise in one style, the two types of methods have different, complementary strengths and when used together can lead to a more comprehensive understanding of a phenomenon. [21]

3.3. Case study

Case study research excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research. Case studies emphasize detailed contextual analysis of a limited number of events or conditions and their relationships. Researchers have used the case study research method for many years across a variety of disciplines. Researcher Robert K. Yin defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

Critics of the case study method believe that the study of a small number of cases can offer no grounds for establishing reliability or generality of findings. Others feel that the intense exposure to study of the case biases the findings. Some dismiss case study research as useful only as an exploratory tool. Yet researchers continue to use the case study research method with success in carefully planned and crafted studies of real-life situations, issues, and problems.

In this thesis, the analysis of the traffic accident and selection of the route with a minimum ratio of traffic density to road capacity for the whole road in the city could not

with in the scope of the research. Therefore, a case study on selected route is the best thing to do. Four alternative routes are selected for the study. Keeping the starting point, source, at Bole – roundabout and the ending point at 6-kilo roundabout.

Definition of each route as follows,

Path one: *Bole – Bole Medhanialem – Urael – Cassanchise Total – Betemengist*

– 6 kilo.

Path Two: *Bole – Olympia – Estifanos – Supermarket – Betemengist – 6 kilo*

Path three: *Bole – Olympia – Bambis – Cassanchise Total – Betemengist – 6 kilo*

Path Four: *Bole – Olympia – Estifanos – Ambassador – Yedirow Kera – 6 Kilo.*

Those routes are selected in this thesis because of the following reasons:

- The assumption in the thesis is that difference in length of routes is not significant.
- There is no short term plan from the federal Road Transport Authority to construct any rerouting at that areas, therefore by managing the pick hour traffic density and distributing the demand to all roads there will be a possible solution in decreasing traffic accident.
- High traffic flow exists in these networks and hence high possibility for accident.
- Available traffic accident data from Addis Ababa Traffic Police Central bureau are not recorded to each road segments. However detail investigating on the data shows that records meant for the roads. Since accident locations are identified by sub city and kebele, those selected routes are mainly used in the stated kebele.

3.4. Data Collection Techniques

Depending on the research perspective and strategy chosen, the researcher must choose methods for collecting data. The data or information collected by the researcher can be either primary, i.e. the researcher collects the material himself, or secondary, i.e. already documented material are being used as a data source, which can be done in either quantitative or qualitative way. In this thesis, both the primary and secondary data are used.

Traffic accident data from Addis Ababa Traffic Police Bureau and insurance companies is collected. Field survey is attempted for the collection of actual traffic flow of vehicles in the selected network.

For the field data collection a tally procedure is followed to count the number of vehicle, which pass a given point. Continuous data is collected, and it is grouped in to ten-minute data, for the daily record.

Road characteristics are measured on the actual field observations. In here, the length of each segment, the number of junctions and intersection are counted. The curvature, horizontal and the vertical curvatures are the parameters of the road that could be referred from the initial design of the road, and this will be part of further development of the thesis.

Actual time taken to cover the distances from the starting point “Bole” to ending point, “6 – Kilo”, is also measured by travelling together with the flow, keeping the same pace of the moving queue vehicle.

Traffic accident, which is called a risk in this thesis, is also collected from the police record. The data for the risk is engaged with the type of road as straight and non-straight; with the time of the date and the driving experience and type of vehicles at the incident of crashing.

Chapter

4

4 Sources of Data And Statistics

4.1 Introduction

This chapter presents a background on some of the data that were used for the purposes of this thesis. Such data include road mileage and the number of vehicle miles travelled. Also included in this chapter is an overview of the national accident trends and statistics for the past decade with a focus on year 1997 E.C. It is important to note at this point that not all data presented below were used in the development of the accident rates. Part of the data presented served as a fundamental background in order to understand the national trends and definitions of various variables closely related with the development of the accident rates. In order to construct the statistical foundation for the development of the safety model, a variety of sources were considered as a source of data. Such sources included Transportation Statistics Annual Reports.

It is important to emphasize that all the data presented in this thesis refer to the years 1985 - 1997 that was fully available at the beginning of this study. The context of this chapter includes sections with comparisons of reported accidents during the past years, accident rates and highway mileage with vehicle miles travelled on different facility classes in the Addis Ababa streets. Highway statistics are required in order to match the frequencies produced by the database, to exposure.

The purpose for presenting the trends is primarily to have trends from other sources to provide a benchmark for evaluating approach. Also, the approach presented in the thesis will demonstrate the computation of accident risk based on crash frequency and vehicle mile travelled (VMT).

4.1.1 Location of the Site Observation

In this section, some background statistics for the transportation network are presented. Data were drawn from the Publications of the Bureau of Federal Road Transportation Authority Statistics. The research was conducted on Bole to 6 – kilo roadways, more precisely in each road segments for the predefined route. This road has 4 - 5 km in length and the pavement width varies from 6m m to 12 m in for t segments in the route. The design speed of this particular road is 40 - 60 km/h.

4.1.2 The Existing Transportation Network In Addis Ababa

The roadway extent and characteristics are hereby examined before analysing in more detail the development of the accident rates. Addis Ababa transportation network is increasing yearly. Many factors influence the expansion and growth of this network such as population increase, economy expansion, higher consumer incomes and vehicle availability. As mentioned in the literature review, many studies involving the development of accident rates and models focused on a particular facility type, i.e. arterials.

For the purposes of this study, the roadway system is divided into five facility types as;

Interstates are limited access divided facilities of at least four lanes.

Principal Arterials are major streets or highways serving high volume traffic corridor movements that connect major generators of travel.

Minor Arterials are streets and highways linking cities and larger towns in rural areas in distributing trips to small geographic areas in urban areas.

Collectors in rural areas are routes serving intra-county, rather than citywide travel. In urban areas are streets providing direct access to neighbourhoods as well as direct access to arterials.

Locals are those roads and streets whose primary purpose is feeding higher order systems, providing access with little or no through traffic.

Thus the category of roadway in this thesis is labelled as collectors and locals.

Despite the fact that the total road mileage in Addis Ababa increased only 3 percent from 1985 to 1997, the total number of vehicles using the roadways has increased much faster, about 5 percent. This significant increase in the number of vehicles increased the total vehicle km travelled during that contribute for the increase in road traffic accidents.

4.2 Accident Statistics

Every year the Bureau of Transportation Statistics and Addis Ababa Central Police Bureau publishes several documents that summarize various transportation safety issues. In this section, some of the available data will be discussed, together with some summarized tables.

4.2.1 Police Reported Accidents – Trends

Over the last decade, the number of police reported accidents varied significantly. Numbers for police reported accidents experienced a decline from 1998 up to 2001 when a rise started that brought the number back to the same level during 2003, and rapid increase to 2005. Figure 4.1 below illustrates the trend that the total numbers followed during the past decade.

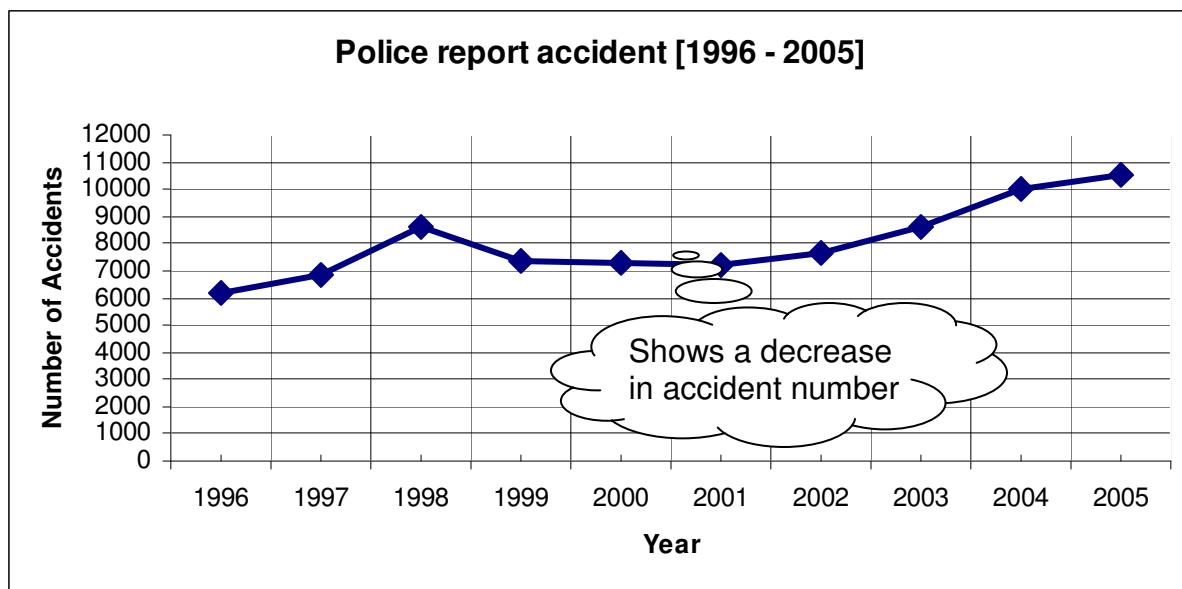


Fig. 4.1 Police Report Accidents for the Year 1996 to 2005 [Addis Ababa Traffic police central bureau]

If we examine these figures closer, we can observe the different components of total reported accidents. The total figure consists of property damage, fatal, serious and light injured accidents.

Figure 4.2, shows the percentage change in the number of accident, with the initial point 0% taken at accident for 1996. Thus, except for the three years 1999, 200 and 2001, the accident rate is increased. The percentage increments were very sharp from 1996 to 1998 (a gross of 29%). Currently, from 2004 to 2005 although an increase in the percentage, it showed a decrease compared from the previous years.

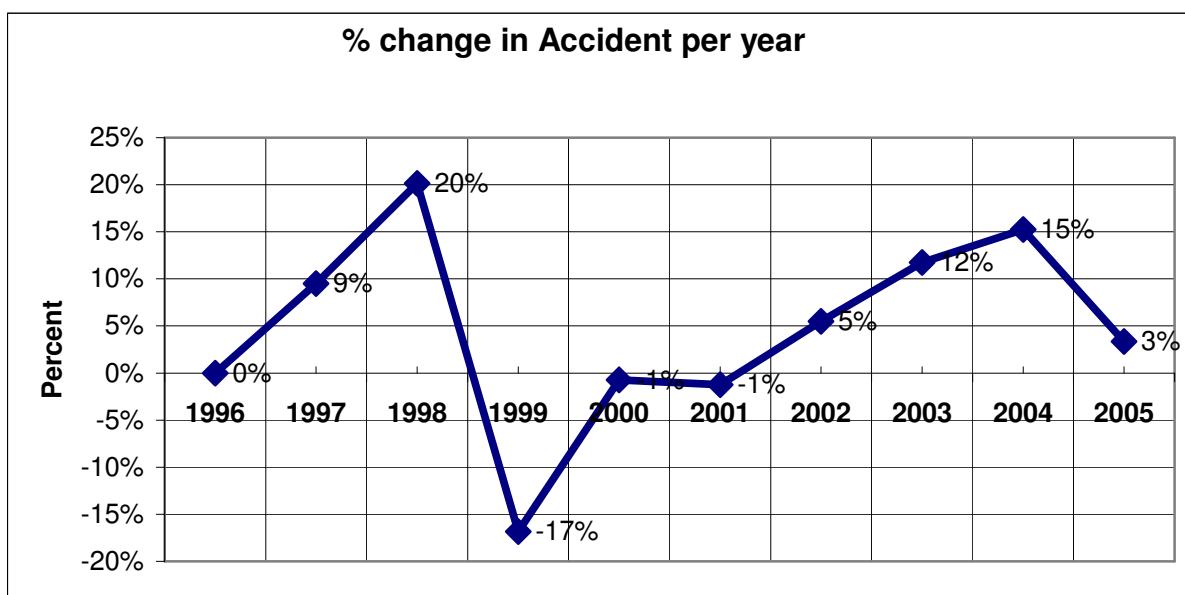


Figure 4.2 Number of accident change in percentage [1996 – 2005]

Figure 3.2, below, also indicates the trends of accident by day of the week. In here, most of the accidents occur at weekdays including Saturday, shows uniform growth. All Sunday Accidents are relatively decreased. The cumulative accident trend by day, fig 4.3, indicates that there is a decrease in accident number on Wednesday, although at all other days the rates are uniform.

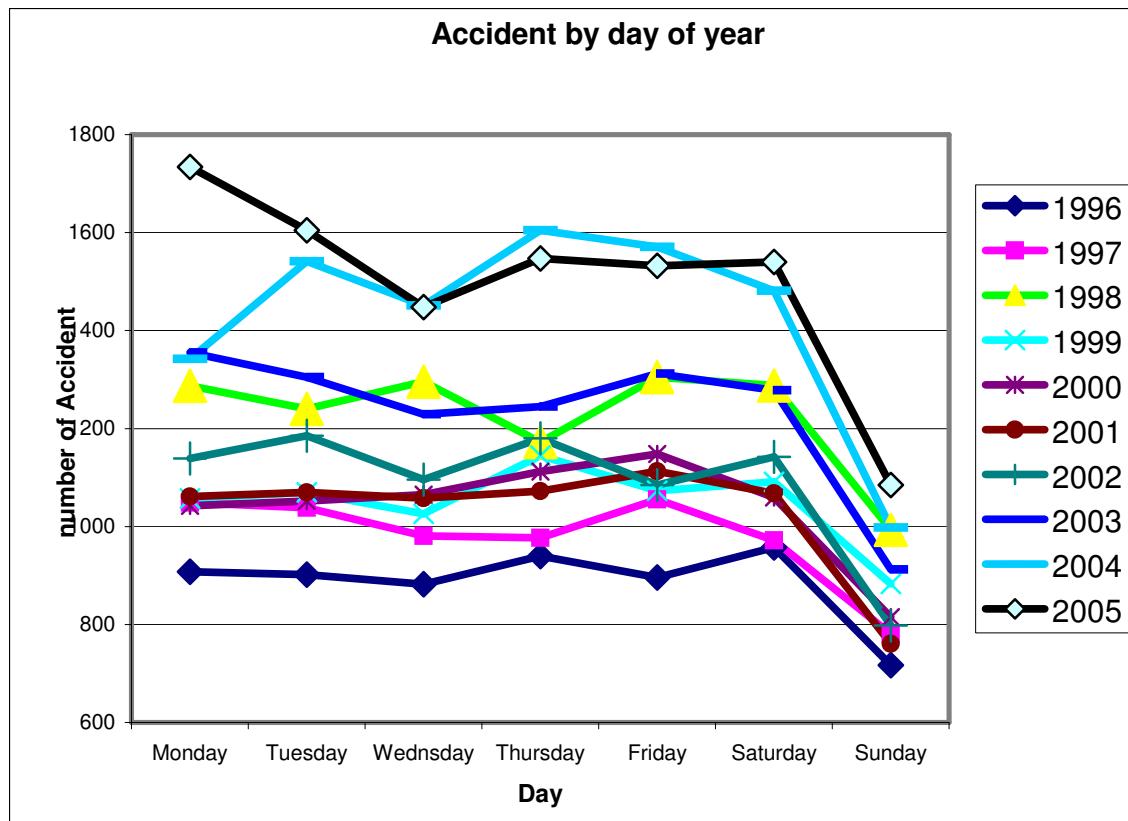


Fig 4.3 Accident trend by day of the week.

To support the above statement the relationship between these parameters, Day of the week and number of accident, have to be analyzed, as shown below. [Appendix F]

Null hypothesis: - is that the two classifications, viz., the number of accident for each year and days of the week are independent. (Alternative hypothesis is that the two the two classifications are interrelated).

Where m = number of columns, and n = number of rows; m = 10 and n = 7.

Assuming significant level 0.05 and degree of freedom v = $(m - 1)(n - 1) = 54$;

$$Expected\ Value = \frac{(Row\ Total) \times (Column\ Total)}{Overall\ Total} \quad 4.1$$

The calculated value for each cell in the table is shown below.

Table 4.1 Expected values

Expected value - [Test: Relationship between num. of accident and day of week]										
	Year									
Day \ Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Monday	938.3	1036.6	1298.2	1111.2	1103.3	1089.7	1153.1	1306.5	1541.5	1595.0
Tuesday	925.6	1022.7	1280.7	1096.2	1088.5	1075.0	1137.6	1288.9	1520.7	1573.5
Wednesday	892.7	986.2	1235.1	1057.2	1049.7	1036.7	1097.0	1243.0	1466.5	1517.5
Thursday	924.5	1021.4	1279.1	1094.9	1087.1	1073.7	1136.2	1287.3	1518.8	1571.6
Friday	931.8	1029.5	1289.2	1103.5	1095.7	1082.2	1145.2	1297.5	1530.8	1584.0
Saturday	915.3	1011.3	1266.4	1084.0	1076.3	1063.1	1124.9	1274.5	1503.7	1556.0
Sunday	673.8	744.4	932.2	797.9	792.3	782.5	828.0	938.2	1106.9	1145.4

Then the comparing value for Chi – square test is calculated given the expected values, as calculated above and the observed actual traffic police data. Using the equation below, the calculated values are shown in table 4.2 below.

$$\chi^2(Obs) = \sum_{j=1}^c \frac{(O_j - E_j)^{(2)}}{E_j} \quad \dots \quad 4.2$$

Table 4.2 X² (Observed)

Observed value calculated - [Test: Relationship between num. of accident and day of week]											
	Year										
Day \ Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total Sum
Monday	1.0	0.1	0.1	2.6	3.4	0.8	0.2	1.8	0.0	12.1	22.1
Tuesday	0.6	0.2	1.3	0.6	1.2	0.0	2.0	0.2	0.3	0.7	7.2
Wednesday	0.1	0.0	3.0	0.9	0.2	0.4	0.0	0.2	0.2	0.2	5.3
Thursday	0.3	1.9	9.0	2.3	0.6	0.0	1.7	1.4	4.9	0.4	22.4
Friday	1.4	0.6	0.2	0.8	2.5	0.9	3.2	0.2	1.1	1.7	12.5
Saturday	1.9	1.5	0.4	0.0	0.3	0.0	0.3	0.0	0.3	0.2	4.9
Sunday	2.8	1.7	4.0	9.1	0.7	0.6	1.1	0.7	10.7	3.2	34.5
										Grand. Sum	108.85456

Calculated Results

χ^2 (Observed) value = 108.85

V_{calculated}= 54

Contingency table Results

χ^2 , Critical value } 67.50 , v = 50
} 79.08, v = 60

χ^2 (*Observed*) > χ^2 , *Critical*; therefore the two classifications are highly related. Similar approach has implemented for the time Vs Number of accidents; Seasonal effect, Months of the year and accident number.

4.2.2 Crashes By Time-Of-Day

Something that we also need to examine is the time-of-day that the crashes occur and what is the distribution during peak and off peak hours. Figure 3.3 below presents the trend for 1996 - 2005 (Addis Ababa Traffic Police Central Bureau Data). It is observed that there are more crashes reported during the morning peak in the intervals of 0700 – 1200 hours and in the afternoon during 1500 - 1800 hours. For the rest of the day, the numbers are very close with the only exception, around the night from 2100 – 0600 hours.

As shown in figure 3.3, it is observed from the graph that there is a uniform pattern for the occurrence of peak accident during the working hours. The plot can be divided in to three sections.

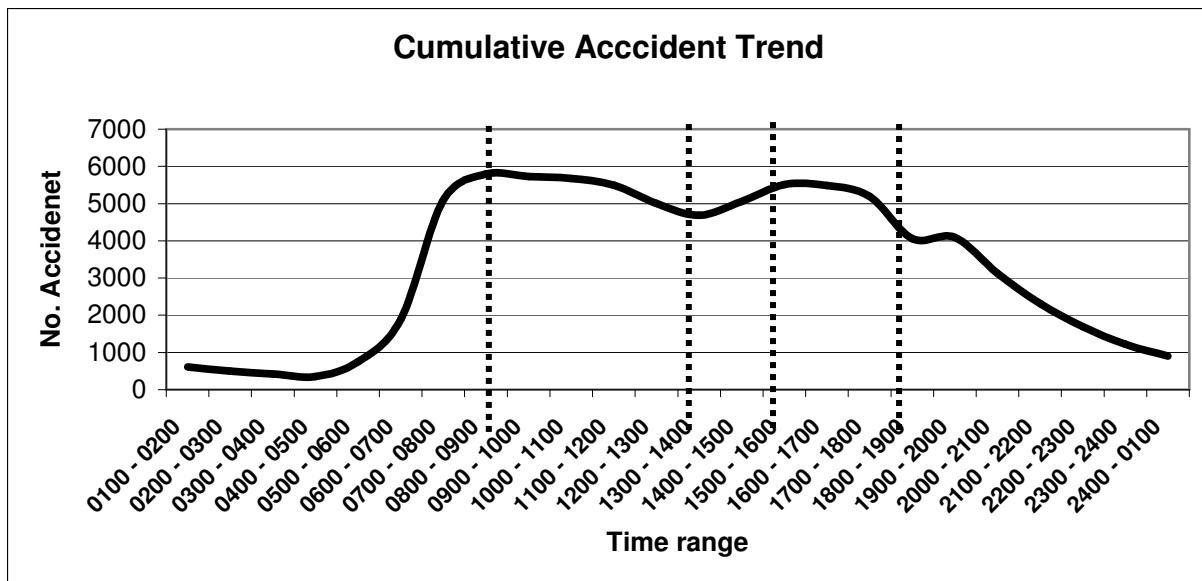


Fig 4.4 Accident trend by time of the day [cumulative for the year]

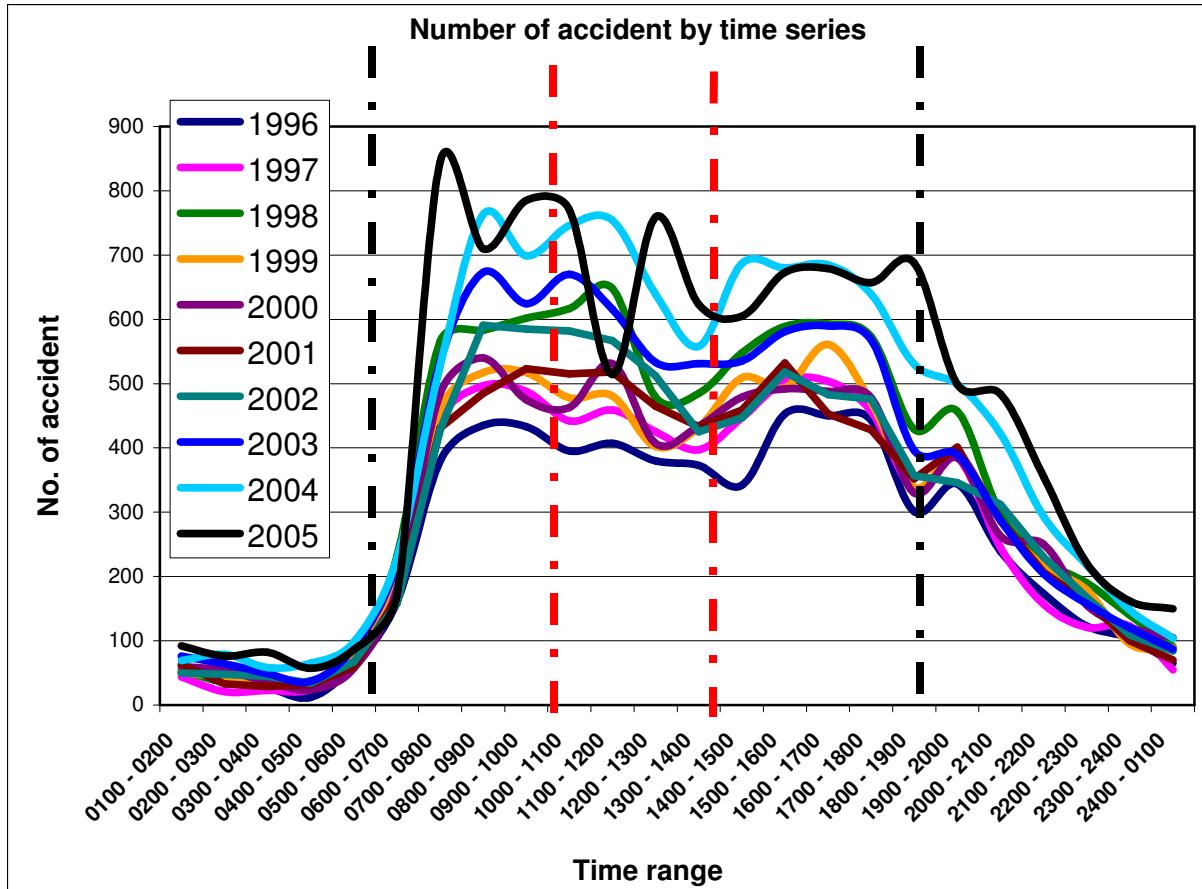


Fig 4.5 Accident trend by time of the day for each year

The Pareto chart, figure 3.4 below, shows that during the time of the day between 0800 – 1100 and 1500 – 1600, Pareto category “A” which is 20% of the whole time interval, are the most critical ranges of high risk to accident, and 80 % of the accidents recorded at this time intervals. If required to treat for 50% of accidents, the Pareto category “ B” have to be included.

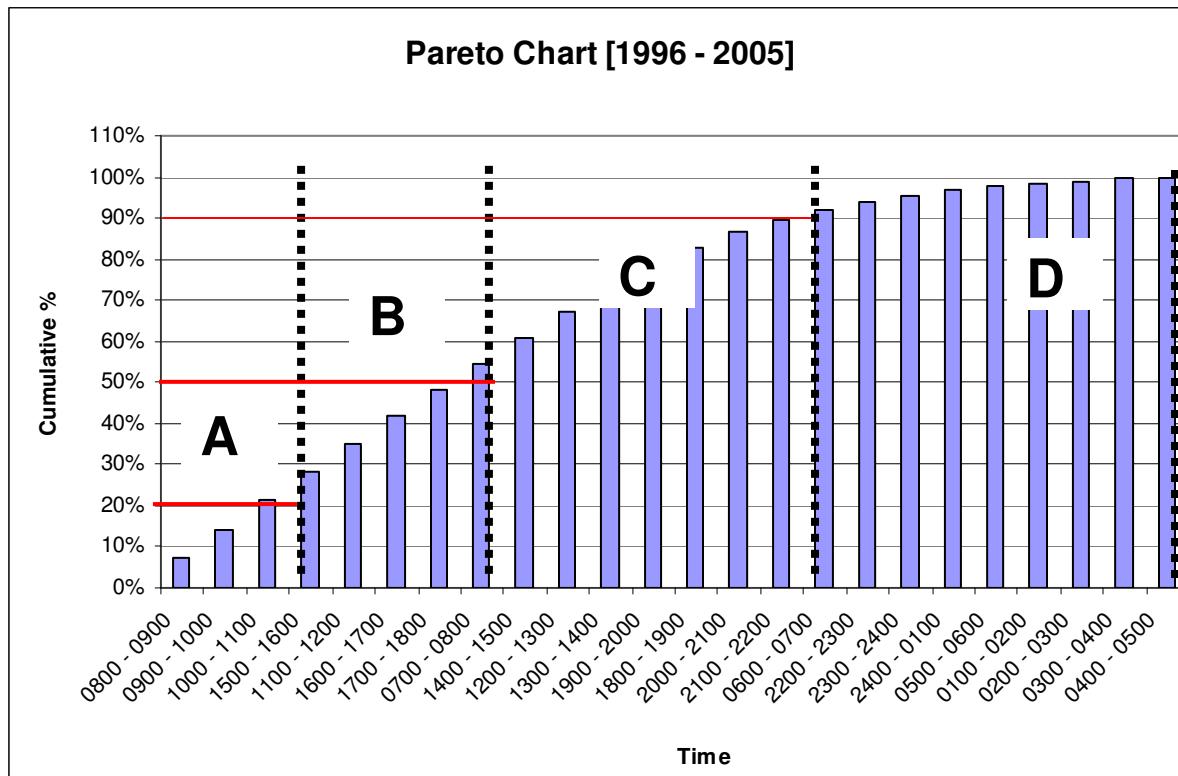


Fig 4.6 Accident trend by time serious – Pareto Analysis

It is clearer from figure 4.6 that in most of the 24 hours time, accident rate contributes much for the 80 %. That is only around the mid night to the early morning that accident rate relatively lower. Otherwise, a uniform trend is followed as shown in figure 4.5.

It is evident from Table 4-3 below that there is an almost constant trend in the reported accidents during the last ten years. An average of 74 percent of the police reported accidents involve property damage only when another 22 are injury-related accidents.

Table 4.3 Crash-by-Crash Severities, 1996 - 2005

Year	Fatal	Fatal %	Injured	Injured %	Property Damage	Property %	Total
1996	286	3.48%	1682	20.44%	6134	74.54%	8102
1997	264	3.21%	1601	19.46%	4987	60.60%	6852
1998	273	3.32%	2014	24.47%	6254	76.00%	8541
1999	280	3.40%	1879	22.83%	5186	63.02%	7345
2000	300	3.65%	1873	22.76%	5120	62.22%	7293
2001	268	3.26%	1846	22.43%	5089	61.84%	7203
2002	269	3.27%	1841	22.37%	5485	66.65%	7595
2003	319	3.88%	1879	22.83%	6429	78.13%	8627
2004	305	3.71%	2045	24.85%	7839	95.26%	10189
2005	320	3.89%	2112	25.67%	8111	98.57%	10543
Total	2884	35.05%	18772	228.12%	60634	736.83%	82290
Average	288.4	3.50%	1877.2	22.81%	6063.4	73.68%	8229

4.2.3 Crashes By Month of the Years: Series analysis of monthly traffic accident

Before applying the methods of time series analysis, it is advisable to check whether our data is time dependent or not.

The method I preferred to use here is the turning point test.

The data, which are used here, are the monthly road traffic accident in Addis Ababa from the year 1995 to 2005,a total of 132 observations for eleven years.

(A) Test of randomness

Turning point test

For our data, P=63, n=132

$$E(p) = (2/3)(n-2) = (2/3)(132-2) = 86.67$$

$$Var(p) = (16n-29)/90 = (16(132)-29)/90 = 23.144$$

(B) Hypothesis to be tested

H_0 : the series is random (time independent)

H_A : the series is not random (time dependent)

Let's take $\alpha=0.05$

Test statistic

$$Z_{\text{cal}} = (p - E(p)) / (\text{var}(p))^{1/2} = (63 - 86.67) / (23.144)^{1/2} = -4.92, |Z_{\text{cal}}| = |-4.92| = 4.92$$

But, $Z_{\alpha/2} = Z_{0.05/2} = Z_{0.025} = 1.96$

Conclusion: since $|Z_{\text{cal}}| > Z_{\alpha/2}$ we reject H_0 at 0.05 level of significance and conclude that the series is not random.

Crash by time of the day indicates uniform pattern on the average values for ten years accidents. On the literature review there is also a seasonal effect on the number of accident, which in the raining seasons the trend increased as compared to other months. In Addis Ababa also holds the same trend. Figure 4.3, below indicates a sharp increase in the number of accidents from July to August. On an average the number of accidents increase 21 % for July - August of 1996 to 2005

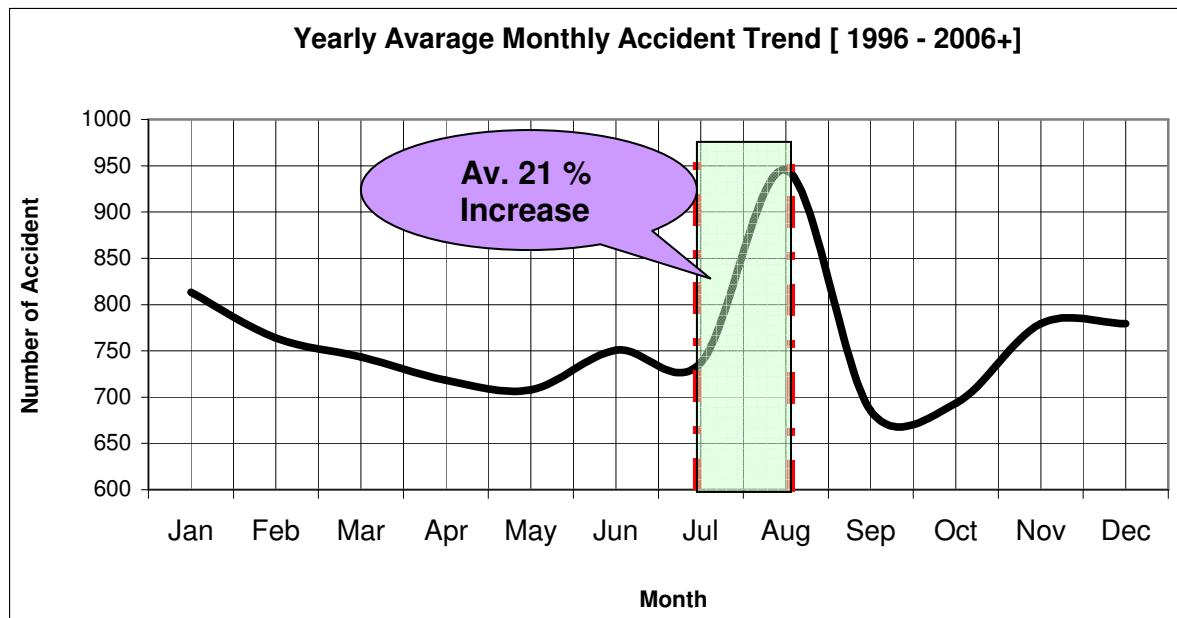


Fig. 4.7 Monthly Number of Accident Trend [averaged monthly for 1996 to 2005.]

The detail of each month, with respect to months of the year, regarding variation in the number of accidents is shown in figure 3.4. As stated above on the yearly average

monthly trend, there is a uniform increment in the number of accident on July – August. The incomplete data, thick black line in the figure is data result for seven months of 2006, where the data is extracted to end of April 2006.

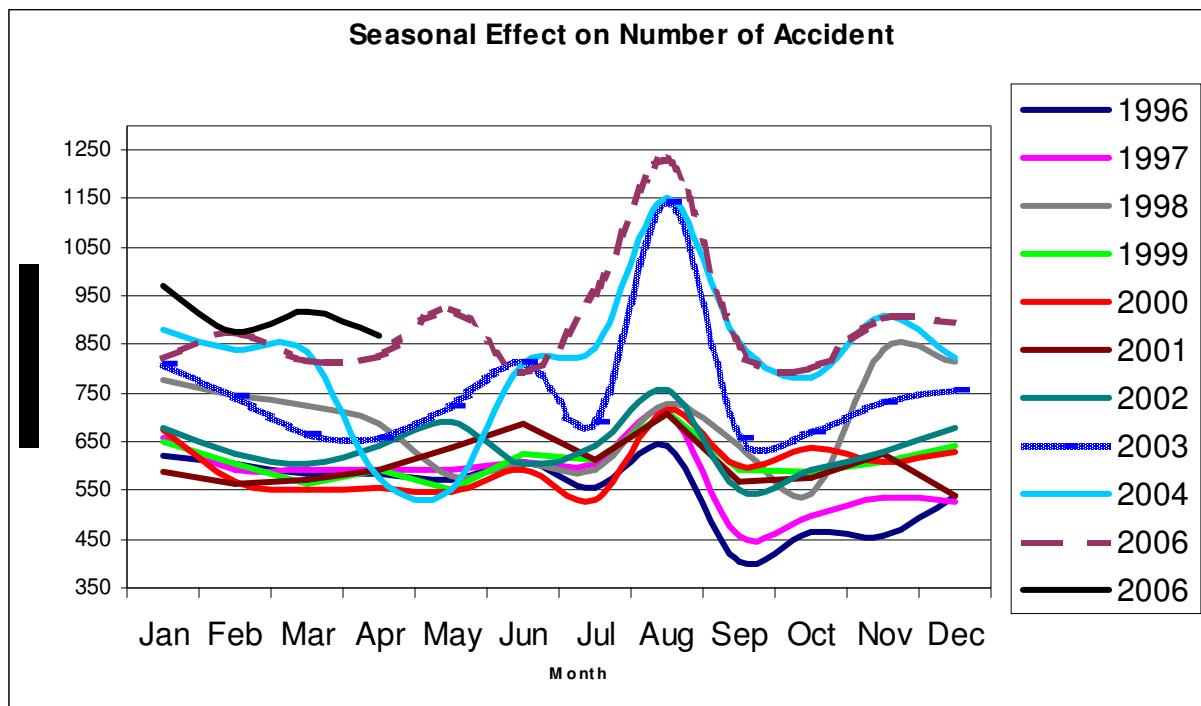


Fig. 4.8 Monthly Number of Accident Trend [1996 to April 2006]

4.2.4 Crashes By Manner Of Collision

Traffic accidents could be categorized by manner of collision per year, in general, for ease of statistical analysis. The most common types are rear-end, head-on, angle, sideswipes, pedestrian, pedal-cyclist and other single vehicle accidents. Figure 3-5 below illustrates the above-mentioned manners of collision. Crashing with Pedestrian, collision brush – sideswipe, angle crashes and rear-end crashes dominate, which contains about 80% of the whole crash categories.

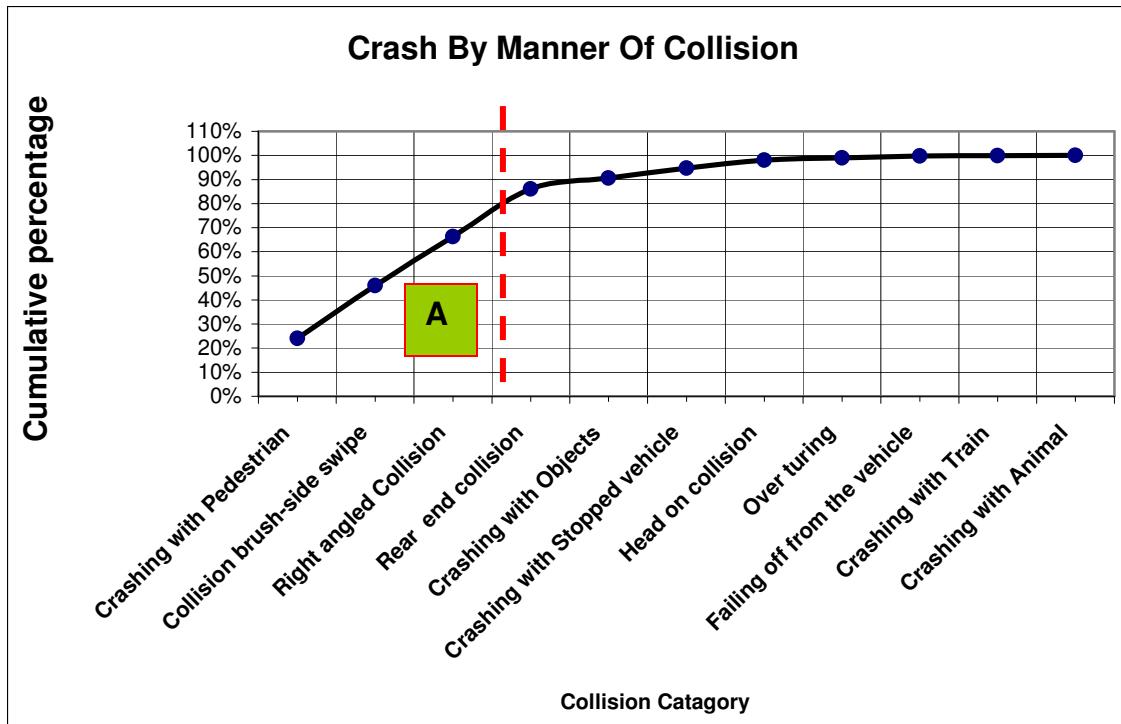


Fig 4.9 Road Traffic Accident by manner of collision

4.2.5 Cost of Crash

The increase in the number of road traffic accident has a direct relation to the cost of crash. Each year the estimated property damage escalated to a higher figure, compared from the previous year. Figure 4.11 below, declares this feature.

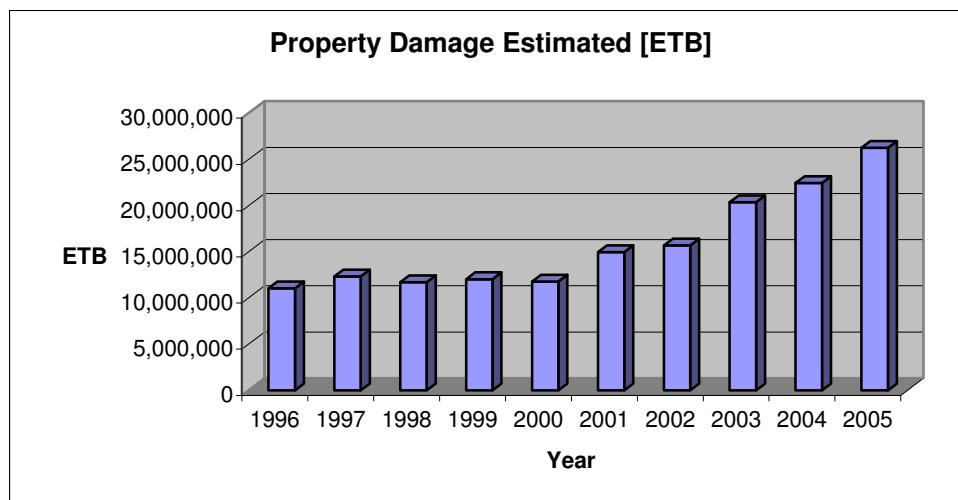


Fig. 3.10 Cost of Crash estimates from 1996 – 2005

The calculation of traffic accident costs is based on injured accidents. In the case of general roadways/ highways, the calculation includes traffic volumes and the number of intersections by distinguishing one-lane and more than one-lanes according to the existence of median barrier and road-location characteristics.

And for basic data of the calculation of traffic accident costs, considering death cost per accident, average accident costs, average loss per physical accident, congestion cost from traffic accidents by road types, it proposes and reflects average accident costs based on injured accidents.

The cost of accident is then finally analyzed using the following:

The accident benefit of a measure is the number of accidents saved multiplied by the appropriate cost per accident.

The value of an accident remedial scheme is usually represented by its first year rate of return, which should normally be at least 15% for consideration for funding:

$$\text{First year rate of return} = \frac{\text{Accident benefit for one year}}{\text{Cost of implementation}} \quad 4.3$$

The statistical data indicates that, the drivers with driving experience with in two to five years are the major participants in the crash. The table for the number of driving licence issue indicates that new driving licence issued in each year is by far more than the number of vehicle growth in the same year. Thus the possibility of getting chance to drive as the driving licence had issued is also less. However, at the incident of accident it is the licence issued date that is recorded as experience. Therefore relation between the number of accident and drivers experience is not strong and thus conclusions drawn from such analysis leads to wrong result.

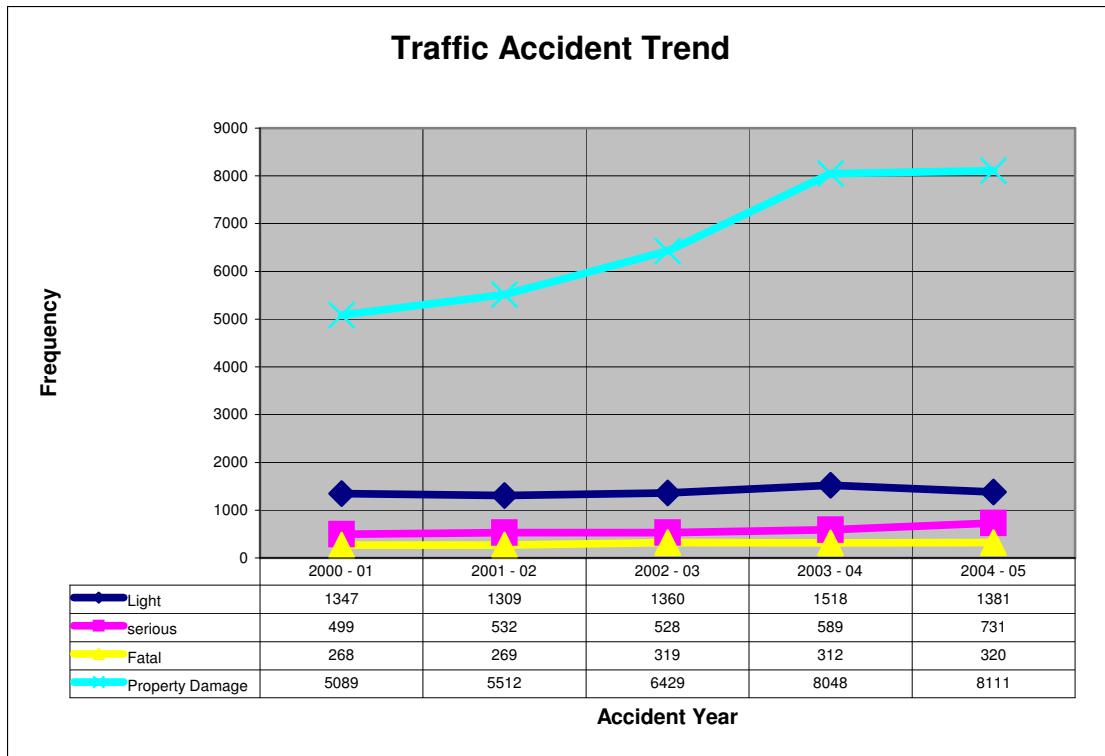
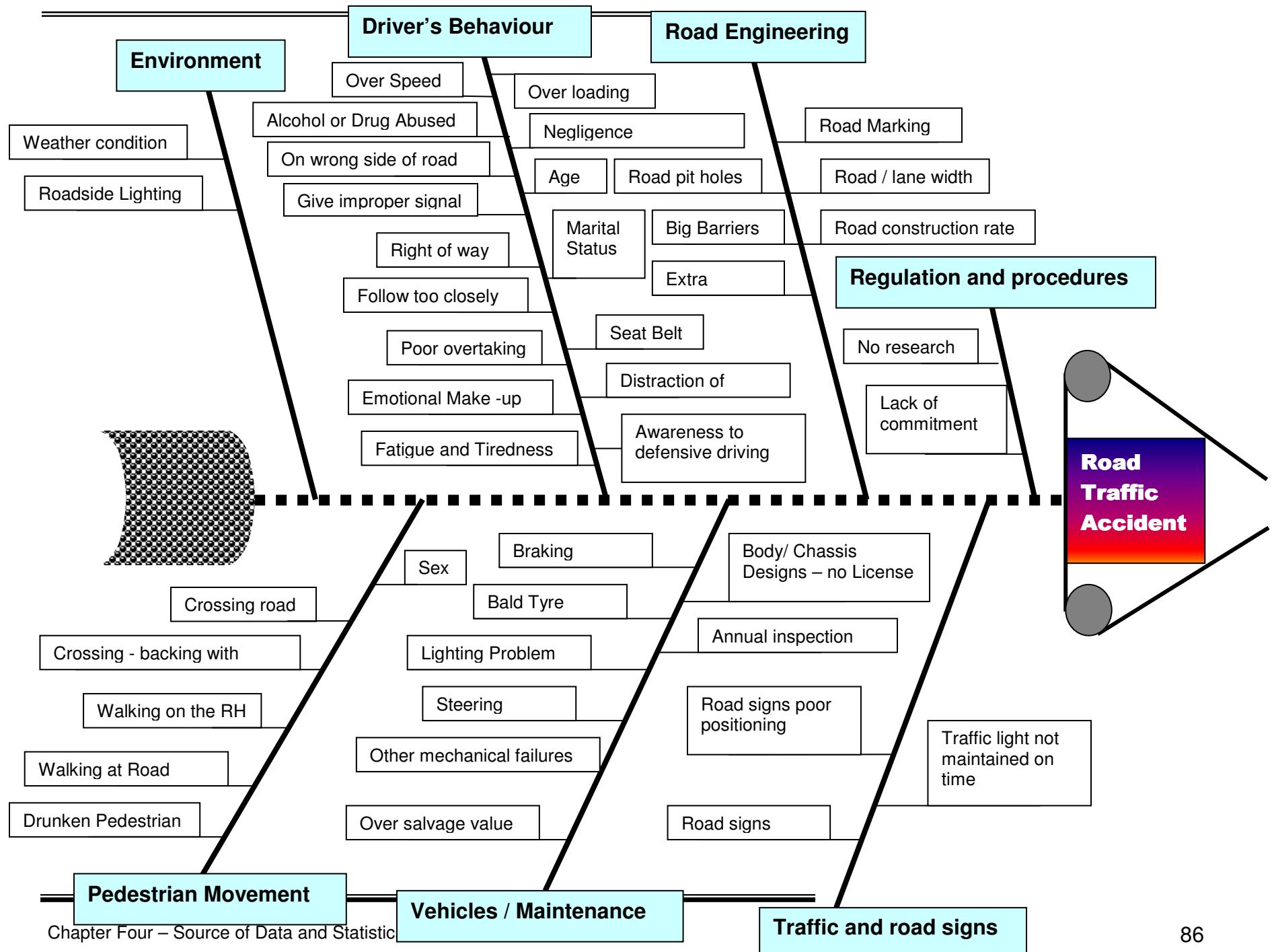


Fig 3.11 accident trend by severity and property damage [2001 – 2005]

4.3 Road traffic accident Root Cause analysis

The cause and effect chart is constructed from the brainstorming and observations. The main causes for the accident are then grouped in to six major parts. The fish bone diagram, fig 9.12 describes the details.



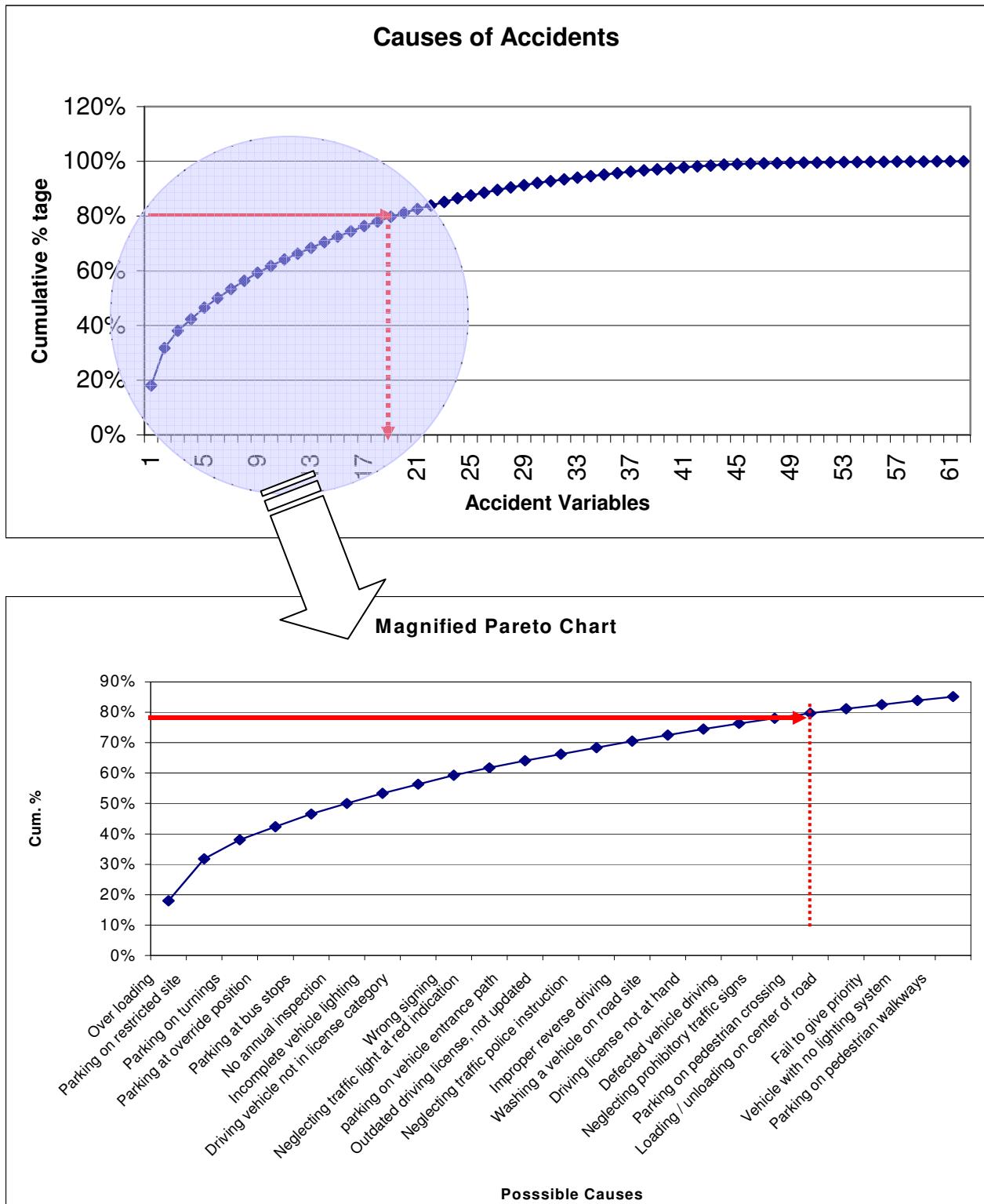


Fig. 4.13 Pareto Analysis Magnified

The figure above indicates the Pareto analysis for the possible causes of accidents. [Appendix H]

The accident causing variables up to number 19 are included for 80% share, which are about 27 % of the total indicated causes.

These causes that contributed for 80 % of the accident is again grouped either as vehicle caused, environmental, drivers fault, etc. as indicated the main groups on the fish - bone diagram, figure 3.13.

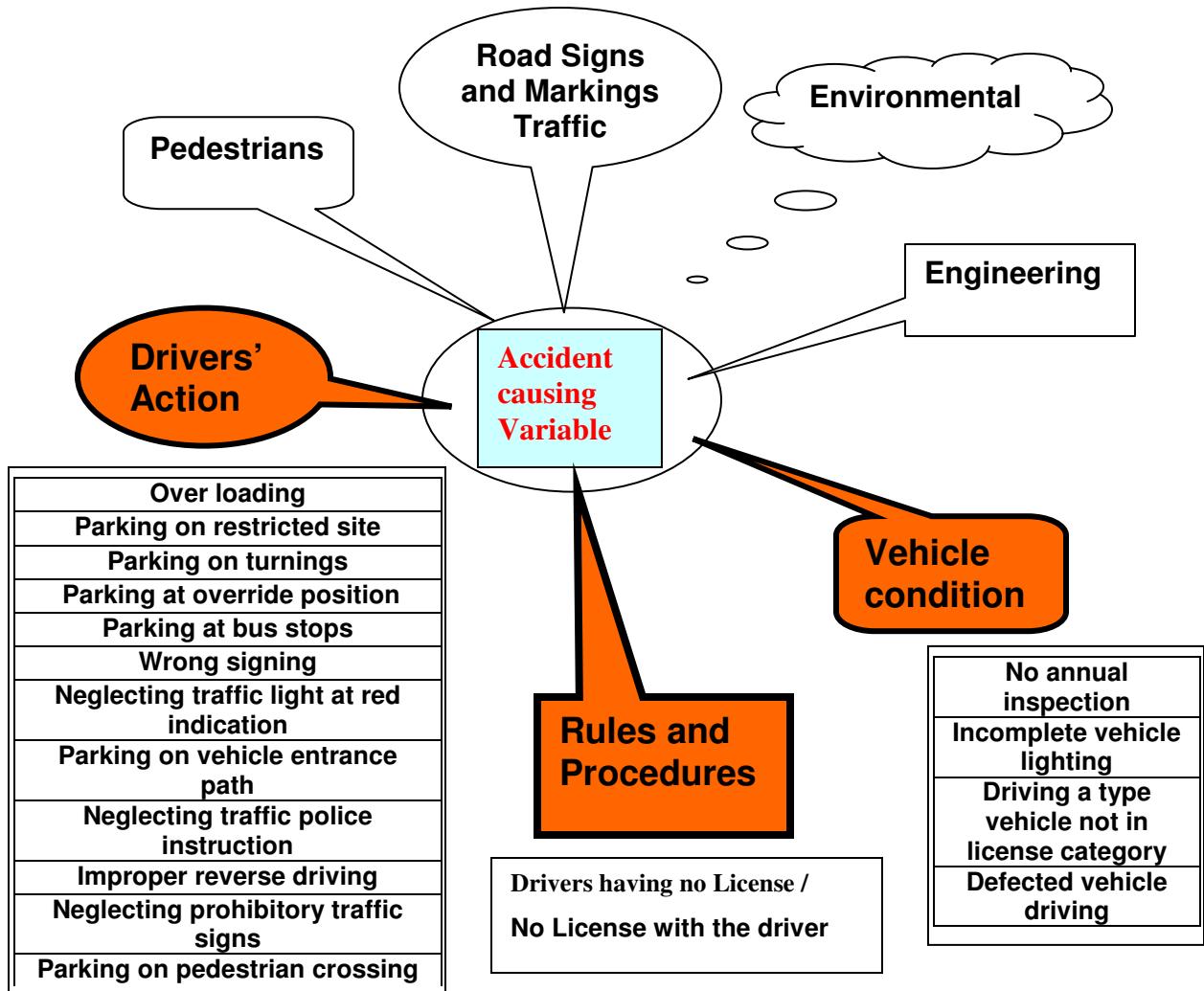
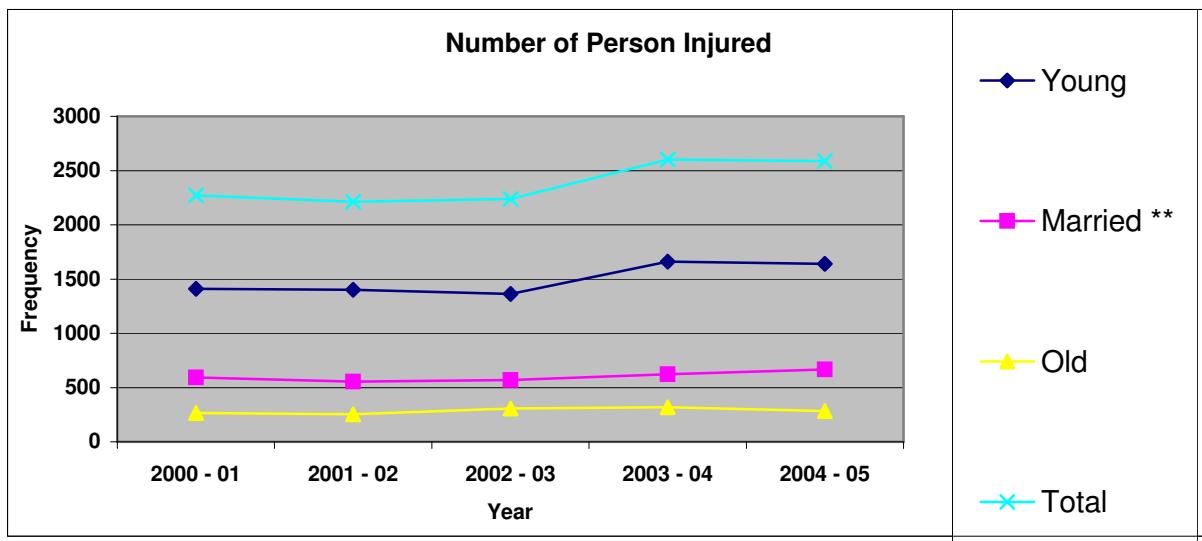


Fig. 4.14 categorizing the causes of accident

The above figure shows that from the 80% accident contributing factors, Driver's action takes major part; 67 % share.

Table 4.4 number of accident categorised by age groups

Accident By Age Group [** 31 - 51 year of age]								
Year	Number of Deaths			Number of Person Injured				
	Young	Married **	Old	Total	Young	Married **	Old	Total
2000 - 01	154	90	46	290	1411	594	266	2271
2001 - 02	112	105	70	287	1401	555	255	2211
2002 - 03	186	82	57	325	1364	569	307	2240
2003 - 04	174	103	68	345	1661	623	319	2603
2004 - 05	172	101	72	345	1639	666	283	2588



Chapter 5

5 Development of traffic accident prediction models by traffic and road characteristics

5.1 Introduction

In the Addis Ababa more people use public transportation every working day.

The railroad network is overloaded and minor incidents lead to a large amount of consecutive delays. Usually, only static information is available. In case of delay it is not easy to find an optimal route based on dynamic data to the planned destination. Even more people travel by car every day. In the rush hours it is observed traffic congestion on the highway and in the cities.

One approach to reduce travel time for individual travellers would be to develop a route planner that incorporates traffic information and public transport possibilities when searching for the fastest route. If congestion occurs along the normal route, the developed software, in visual Basic will search for the best alternative, which may lead the traveller along other alternative to the destination.

Another important issue to be address in this section is the increasing number of accidents, caused by unexpected events on the roads or changing weather condition. Travellers need personal, up to date information to reach their goals in a safe and fast way. A crucial issue is then the communication between travellers, and information system and the communication structure itself. The current research programs assumes to use a central data processing centre and information is disseminated to the vehicles with FM Radio, with a dedicated band to inform the traffic scenarios only.

The current procedure of estimating accident reduction benefit applies fixed accident rates for each road level. . In order to solve the problems mentioned in the previous chapters, models will be developed considering the characteristics of roadway and traffic

characteristics. The developed models will be used to estimate the accident rates on new or improved roads.

First of all, factors influence accident rates were selected. Those factors such as traffic volumes, intersections, connecting roads, pedestrian traffic signals, existence of median barrier, lanes are considered. In this study, the regression analysis has been performed for each group with actual data associated with traffic, roads and accidents. When road types and characteristics change, characteristics of traffic accidents also change but it is not seen yet a proper measure to predict changes of traffic accidents according to traffic characteristics and road types. So this study is to develop a systematic accident prediction model reflected by physical characteristics of road types through a survey of characteristics of roads and accidents in Addis Ababa.

5.1.1 Procedure and Range of Study

The space range of the study is Addis Ababa roadway, where specific routes are selected based on the traffic accident data record history, and the contents range is analyzed as the relations between road characteristics and traffic accidents occurred on the roads in Addis Ababa. The time range has limited the current survey data and accident data. Below are the general outline of procedures for identification, diagnosis and selection of site. The procedure includes;

- Data provision (data collection),
- Problem site and situation identification (presenting accident data for analysis, ranking and numerical and statistical analysis).
- Diagnosis of the site for treatment,
- Select the site for treatment (identification of possible remedies and choice of remedy with assessment of accident benefit).

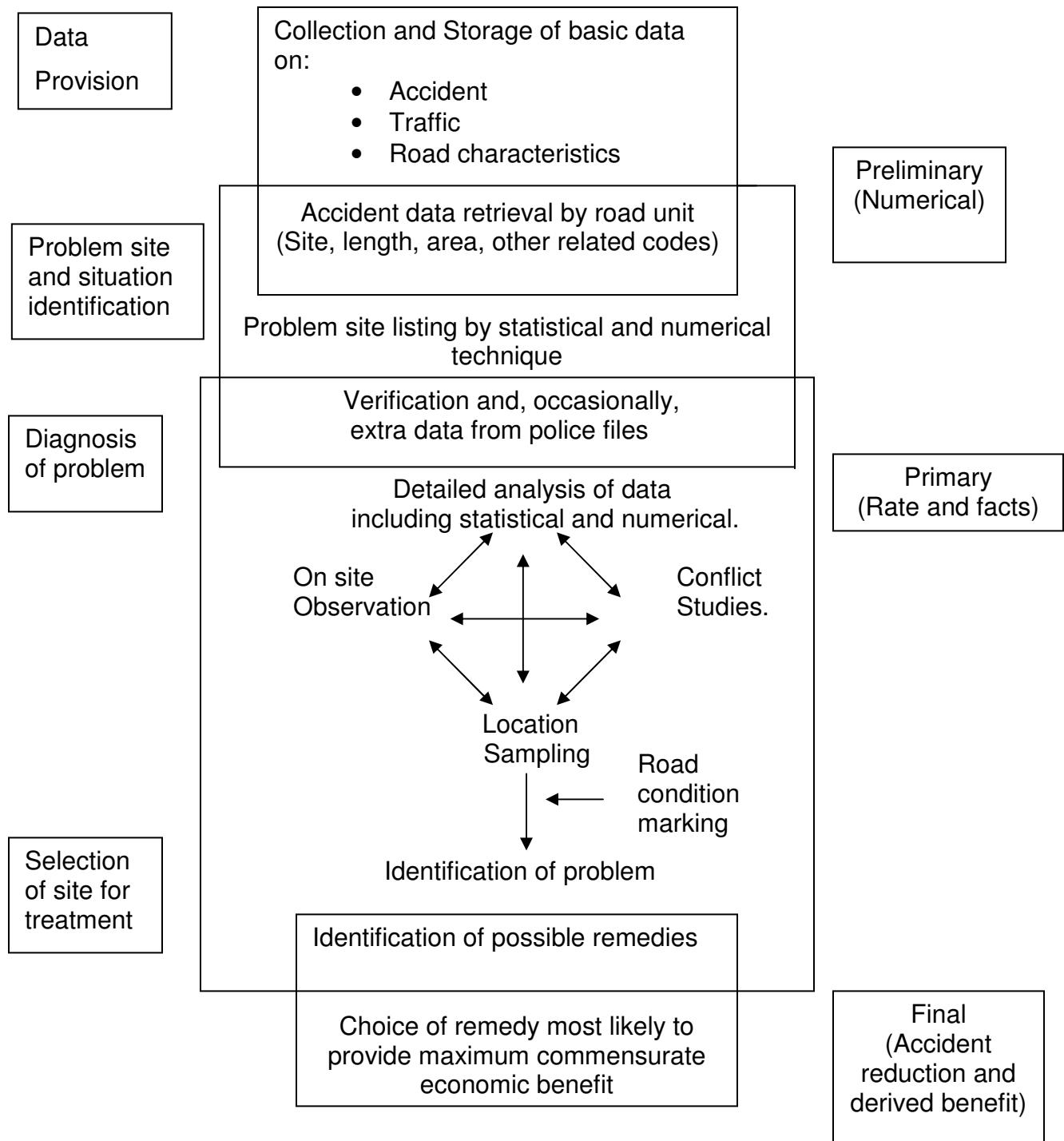


Fig. 5.1 Outline of procedures for identification, diagnosis and selection of sites.

5.1.2 Proposal for a Road Traffic Accidents Prediction System

Real-time road traffic accidents report system can tell you what happens now, but can't tell you what will happen next. Therefore, although you planed your journey according to the real-time report system, you still cannot avoid traffic if the accident just happened. Historic accident data may tell you where might have an accident under some circumstances if they are well organized and visualized. Hence it might be develop predictions based on previous data.

Many factors can affect road traffic accidents, such as weather, road type, junction type, car speed, driving time, and so on. The following sections describe the proposed prediction system in greater detail. The approach to be used to prediction road accident is by averages from historical accident data and predictions from statistical models based on regression analysis. It is very difficult to estimate long-term expected accidents rate using a relatively short-term data. Some location have never happened an accident in the past few years, but some have many accidents. Therefore, current available accident data only give an insufficient basis for estimating long-term road traffic safety performance.

Therefore, statistical technique is another important research method in this study - to build models to predict traffic accidents.

The total prediction formula has two parts, one is predicted accident frequency for all segments, and the other is predicted accident frequency for all intersections. The formula is shown below:

$$N_t = \sum_{\text{all segment}} N_{rs} + \sum_{\text{all intersection}} N_{int} \quad \dots \quad 5.1$$

Where,

N_t = Predicted accident frequency for an entire project or section.

N_{rs} = Road side accident frequency for an entire project or section

N_{int} = Intersection accident frequency for an entire project or section

5.2.1.1 Structure of the Accident Prediction Algorithm

The structure of the accident prediction algorithm, including base models, accident modification factors, as illustrated in figure below. The base model is developed with geometric design, traffic control, traffic volume, and accident data on roadway sections and intersections using negative binomial regression method. Accident Modification Factors (AMFs) represent the incremental effects of individual geometric design and traffic control elements.

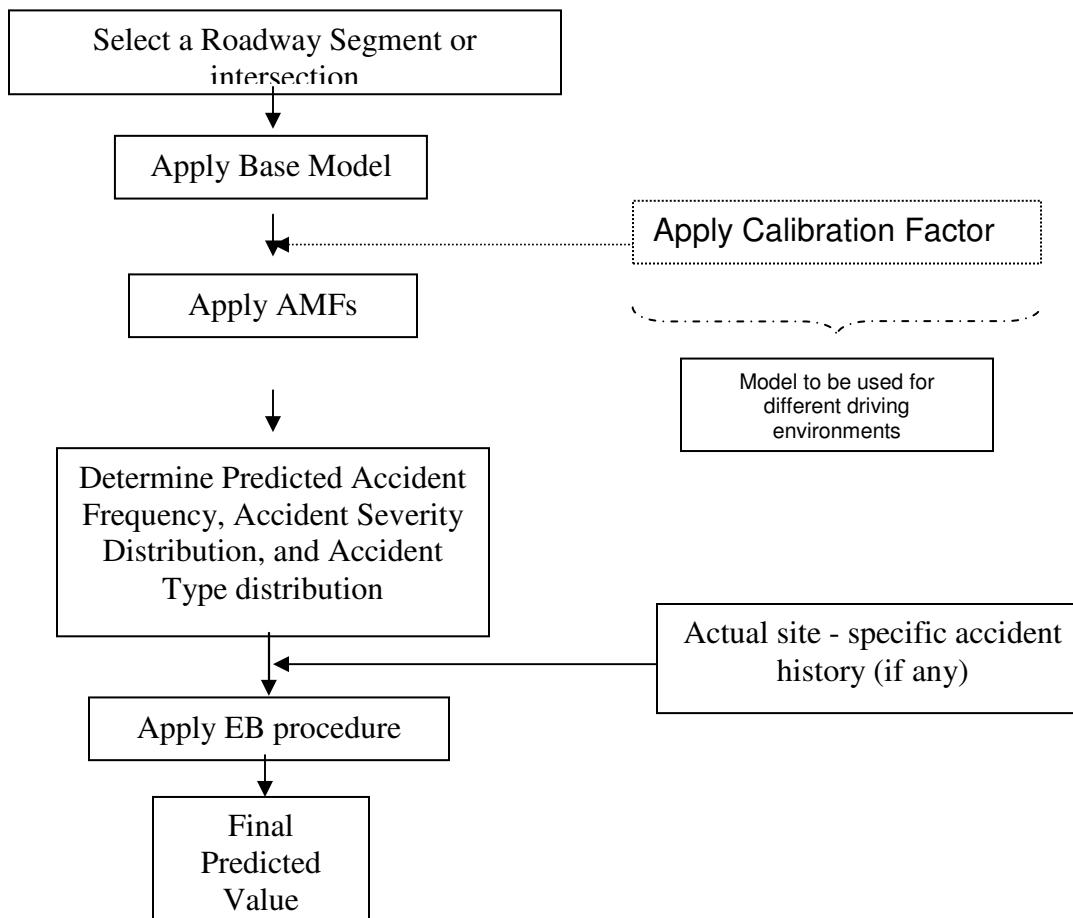


Figure 5.2. Flow Diagram of the Accident Prediction Algorithm

- . “The accident prediction algorithm, as formulated in equations 5.1 and 5.2, below, is based on data for many locations and on expert judgment, but does not take advantage of knowledge of the actual accident history of the location being evaluated. Actual accident history data should be available for many existing locations evaluated with the accident prediction algorithm. For this reason, a procedure based on the Empirical Bayes (EB) approach is provided to combine the results of the accident prediction algorithm with actual site-specific accident history data.”

The general formulation of the algorithm predicting roadway segment accident frequency and combining the base model and AMFs (Accident Modification Factors) is shown below:

$$N_{rs} = N_{br} (\text{AMF}_1, \text{AMF}_2, \dots, \text{AMF}_n) \quad \dots \quad 5.1$$

Where,

N_{rs} = Predicted number of total roadway segment accident per year after application of accident modification.

N_{br} = Predicted number of total roadway segment accident per year for normal or base condition

AMF = Accident Modification Factor.

The AMFs are multiplicative factors used to adjust the base accident frequency for the effect of individual geometric design and traffic control features. Each AMF is formulated so that the nominal or base condition is represented by an AMF of 1.00.

Conditions associated with higher accident experience than the nominal or base condition will have AMFs greater than 1.00 and conditions associated with lower accident experience than the nominal or base condition will have AMFs less than 1.00. All the AMFs were developed by experts' judgment. Developing AMFs is not a simple process. The researcher doesn't have any road geometric data. This need further contact. At the same time, it needs to figure it out that how AMFs are developed by expert judgment to see if it is possible to include AMFs in our own customised prediction function [21].

The base model for roadway segments is presented below, as developed by UK road research centre:

$$N_{br} = \text{EXPO exp} (0.6409 + 0.0254 LW - 0.0177 SW + 0.0668 RHR + 0.00525 DD) \quad \dots \quad 5.2$$
$$(\text{WH}_i \exp (0.045 \text{Deg}_i)) (\text{WV}_j \exp (0.04652 V_j)) (\text{WG}_k \exp (0.1048 GR_k))$$

Where:

N_{br} = predicted number of total accidents per year on a particular roadway segment;

EXPO = exposure in million vehicle-Km of travel per year = $(ADT)(365)(L)(10^{-6})$;

ADT = average daily traffic volume (veh/day) on roadway segment;

L = length of roadway segment (km);

LW = lane width (m); average lane width if the two directions of travel differ;

SW = shoulder width (m); average shoulder width if the two directions of travel differ;

RHR = roadside hazard rating; this measure takes integer values from 1 to 7 and represents the average level of hazard in the roadside environment along the roadway segments.

DD = driveway density (driveways per Km) on the roadway segment;

Wh_i = weight factor for the ith horizontal curve in the roadway segment; the proportion of the total roadway segment length represented by the portion of the ith horizontal curve that lies within the segment. (The weights, WH_i, must sum to 1.0.);

DEGi = degree of curvature for the ith horizontal curve in the roadway per 30m);

WV_j = weight factor for the jth crest vertical curve in the roadway segment; the proportion of the total roadway segment length represented by the portion of the jth crest vertical curve that lies within the segment. (The weights, WV_j, must sum to 1.0.);

V_j = crest vertical curve grade rate for the jth crest vertical curve within the roadway segment in percent change in grade per 30 m = $|g_{j2}-g_{j1}|/l_j$;

g_{j1} - g_{j2} = roadway grades at the beginning and end of the jth vertical curve (percent); l_j = length of the jth vertical curve (in 30 m);

WG_k = weight factor for the kth straight grade segment; the proportion of the total roadway segment length represented by the portion of the kth straight grade segment that lies within the segment. (The weights, WG_k, must sum to 1.0.); and

GR_k = absolute value of grade for the kth straight grade on the segment (percent).

From the research centre of India on accident rate, AR, and road features; the empirical formula is as followed.

$$AR = 0.2171 + 0.002884 CV + 0.4126 J - 0.3447 W + 0.001274 Q_{ADT} \quad \dots \quad 5.3$$

Where, AR = accident rate in number per km per year

CV = curvature in deg/Km

$$J = \text{Number of junction/Km}$$

W = Pavement width in m

Q_{ADT} = Total Volume in terms of Vehicle per day.

Table 5 .1 Road Parameters and number of accident [one year data – 2005]

Route Segments	Actual Accident/Year	Number of Lane/direction	Median Barrier [yes = 1; no = 0]	Number of Intersection	Number of Connection
Bole to Olpmia	414	3	1	2	6
Betemengist to 6 kilo	209	3	0	3	4
Estifanos to Ambasador - "YediroKera"	159	2	0	3	3
Bole Medhanialem to Urael	137	3	1	2	1
Olompia to Bambis - Cassancise Total	109	2	1	3	2
Estifanos to Betemengist	100	3	1	3	2
Olompia to Abiyot/ Estifanos	84	3	1	2	6
Urael to Cassancise Total	79	2	1	3	3
Bole to Bole Medhanialem	71	3	1	2	2
"YedirowKera" to 6 Kilo	71	1	0	3	4
Cassancise Total to 6 killo	50	3	1	3	4

If the data on the road and the collected accident numbers are matured, it is possible to develop a relation (linear, exponential, logarithmic, etc.) between the number of accident, Y, and the road parameters. Note that the relation shown below is based on the average traffic flow per hour. However, the traffic flow varies in the time of the day, where the maximum is expected at pick hours. Therefore, the predicted accident is within 5% of the actual data. Below is the accident prediction linear equation for the segment “Bole to Olympia”.

$$Y = 0.341 \times (X_1) + 0.491 \times (X_2) - 336 \times (X_3) + 0.684 \times (X_4) + 0.458 \times (X_5) \quad \dots \quad 5.4$$

Y = Number of accident per kilometer per year

X_1 : Traffic Volume (vehicles/hour)

X₇: Number of Lane (unit/km)

X₃: Median Barrier [0 if no Barrier and 1 if Barrier]

X₄: Number of Intersection (unit/km)

X₅: Number of Connections (unit/km)

Chapter 6

6 Dynamic Vehicle Routing System: Network Analysis

6.1 Introduction

Road traffic is getting busier and busier each year. Everyone is familiar with traffic congestion on highways and in the city. And everyone will admit that it is a problem that affects us both economically as well as mentally. It is very frustrating to end up in a traffic jam just when you were in a hurry. But it is even worse that a lot of people know in advance that every day they need twice as much time as the maximum allowed speed would make possible. Furthermore finding your way in an unknown city can be very difficult, even with a map, especially when you are alone.

One of the reasons for congestions is that road capacity is not optimally used. Route information along the road is focused on “shortest distance”. This information is static. Dynamic route information could exploit the network capacity in an optimal way.

At this moment there is no system that collects and provides dynamic route information for car drivers. This information could be presented at DRIPs (Dynamic Route Information Panels) along the way.

The goal of this system is to route the whole cohort of drivers in an optimal way. This thesis addresses traffic problems in a city considering only the selected cases. It describes a routing system able to guide individual car drivers through a network. Together with that, it deals with a simulation environment that enables experimenting with the routing system in a computer environment.

6.2 Ant-based Control For Network Management

We can use the idea of emergent behaviour of natural ants to build routing tables in any network. We will apply it in a traffic network in a city, i.e. the composition of the roads and their intersections. This network is represented by a directed graph. Each node in the graph corresponds to an intersection. The links between them are the roads. Mobile agents, whose behaviour is modelled on the trail-laying abilities of natural ants, replace the ants.

The agents move across the network between randomly chosen pairs of nodes. As they move, pheromone is deposited as a function of the time of their journey. That time is influenced by the congestion encountered on their journey. They select their path at each intermediate node according to the distribution of the simulated pheromone at each node. Each node in the network has a probability table for every possible final destination. The tables have entries for each neighboring node that can be reached via one connecting link. The probabilities influence the agent's selection of the next node in their journey to the destination node.

The probability of the agents choosing a certain next node is the same as the probability in the table. The probability tables only contain local information and no global information on the best routes. Each time an agent visits a node the next step in the route is determined. This process is repeated until the agent reaches its destination. Thus, the entire route from a source node to a destination node is not determined beforehand. Agents are launched at each node with regular time intervals with a random destination node.

The paper will then explain the algorithm with the aid of a traffic network in a city, i.e. the composition of the roads and their intersections. Such a network can be represented by a directed graph. Each node in the graph corresponds to an intersection. The links between them are the roads. Mobile agents - motorists, whose behavior is modeled on the trail-laying abilities of natural ants, replace the ants.

To provide up-to-date, dynamic route information it is necessary to have access to a database of traffic congestion and up-to-date travel times. Travelers on the route may provide the necessary information themselves. At regular times they send their position to a central database. From that information the time it takes to travel from A to B can be computed. So at the start we have only static route information to provide the shortest routes, but once travelers are on their way, we get recent traveling data.

The next step is to compute the shortest route from A to B based on the existing dynamic route information. We have to realize that all the time the optimal route has to be computed, as soon as the travel times are refreshed. I have chosen the Ant - Base - Control, ABC -algorithm for dynamic routing.

After developing the system, it has to be tested, before it can be implemented in a real world application. So it is necessary to design and implement a test bed, a simulation of the traffic in a city. An application called City consists of both the simulation environment for the traffic and the Control centre, where parameter settings can be changed. The traffic in the simulation communicates with the Routing system. This way we simulate the communication of real vehicles with the Routing system.

The Routing system will consists of two subsystems. The first subsystem is the timetable updating system. This subsystem receives information about the traffic network in the city. This information is provided by the vehicles / Motorcycles driving through the selected nodes in the city. So the proposed system is self-contained. The second subsystem is the Route finding system. This system calculates the shortest routes, in time frame, and the less probable road traffic accident occurrences for all the users on the basis of the information in the table, and database with the travel time slots.

6.3 Routing problem

The most important problem of dynamic routing is solved by the timetable updating system and the route finding system. These two subsystems together form the routing system. The function of the route finding system will be clear: we are building a system

to route vehicles. The reason why we need the timetable updating system is the following. The route finding system needs information about the state of the network. A static route finding system could use a fixed set of data, but we will use a dynamic route finding system that needs dynamic data.

Those data are provided by the timetable updating system. That information can be for example the load of the parts of the network but a more direct and therefore more practical type of information is the time it takes to cover a road. Vehicles send information about their covered route to the timetable updating system. From that information this system computes the travelling-times for all roads and stores it in the timetable in the memory. Besides the timetable also a history of measurements is stored in the memory. The route finding system uses the information in the timetable to compute the shortest routes for the vehicles. When the vehicle requests route information, the route finding system sends this information back to the vehicle.

6.4 Route Finding System Proposed

The Route finding system receives requests for routes from individual motorists. For each motorist the shortest route in time will be calculated and send back to the motorist. This information depends on the time and the location of the vehicle. It consists of an instruction at every crossing where to go next.

The route information is updated at regular times. Routing is of course a very common problem and it is actually very dynamic. This means that the timetable is updated at a very high pace.

Routing is determined through complex interactions of network exploration agents. These agents (ants) are divided into two classes, the forward ants and the backward ants. The idea behind this subdivision of agents is to allow the backward ants to utilize the useful information gathered by the forward ants on their trip from source to destination. Based on this principle, no node routing updates are performed by the forward ants, whose only purpose in life is to report network delay conditions to the backward ants. This information appears in the form of trip times between each network node. The backward

ants inherit this raw data and use it to update the routing tables of the nodes. As all the algorithms inspired from ants life, the system uses probability tables.

Besides these a node i keeps a second data structure, which its main task is to follow the traffic fluctuations in the network. The algorithm works as follows:

1. The mobile agents F_{s-d} are launched at regular time intervals from every network node s (start).
2. Each ant keeps a memory about its path (visited nodes). When an ant arrives in a node i , coming from node j , it memorizes, the identifier of the visited node i , and the virtual delay of the link (the trip time necessary for a car to travel from intersection j to intersection i). These data are pushed onto the memory stack $S_{s-d}(i)$.
3. When an ant comes in the node i , it has to select a next node n to move to. The selection is done according with the probabilities P_d .
4. When the destination node d is reached, the agent F_{s-d} generates another agent (backward ant) B_{d-s} , transfers to it all of its memory, and dies.

However, in this thesis “Ant-based control for network management” could not implemented due to the very limited resource assigned. At each road segment starting point we need a minimum of two mobile agents. After the time “t” where first agent (S_1) released, the second agents (S_2) will follows. Therefore, for the whole route alternatives in this case study, we it is required to have eighteen such agents. Therefore, in substitution for the mobile agents, Stationary data collectors at each road segment are in placed.

The system in this thesis adopted the traffic density per the road capacity (V/C) per each segment. As stated in chapter 3, field observation data, traffic flow, is stratified in to 10 minutes record data.

1. The first time phase: 7:00 am – 9:00 am, three hours interval, is divided in to eighteen groups of 10 minute traffic flow data. Excluding the biased numbers from the group, the minimum and the maximum of the group is recorded.

2. The second time phase: 12:00 pm – 1:00 pm, twelve groups of data
3. The third time phase: 4:00 pm – 6:30 pm, fifteen data groups.

The selected maximum and minimum values of each segment from each the three time phases serve as an input to the dynamic simulation. Those two numbers being the lower and upper boundary, a random number is generated. Monte Carlo Simulation method is adopted such that the generated number is restricted to make the output of Erlange probably equals 0.8. The generated number is then an input to, Erlange probability distribution function. If generated number is larger than the fixed probability value (0.8 in the Vb code) the program will execute the result; otherwise, will generate another number that will satisfy the condition.

6.4.1 Shortest Path

Let d_{ij} , represent distance between two nodes and assumed that the each segments is known. The length of branch (i, j) in the direction from node i to j need not be the same length as travelling in the reverse direction, j to i . In this study only the forward step is considered. If node i does not connect node j , the distance between the two is assumed infinite, or for the sake of digital computation a very large number is assigned.

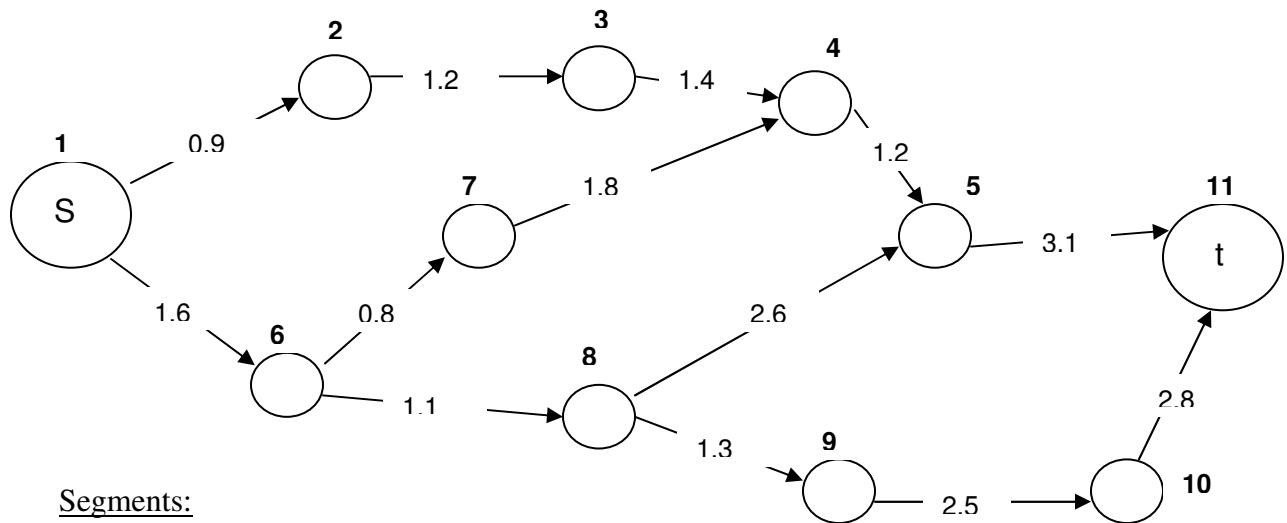
Is known.

Combinatorial Approach:

Attach to the source S the number 0. Proceed in ascending node number from S (which is supposed to be node 1) attaching to each node j which connects with the node written $i < j$, a number. The network in this study is developed for the selected four routes from Bole to 6 kilo.

$$K^1_j = \min \{ K_j; K_j + d_{ij} \} \text{ and } K^1_s = 0, j = s, 2, \dots N - 1, \text{ Destination, "t".}$$

The network, below, is a sample for the four alternative routes from “Bole 6 Kilo”. The labels on the link are the distance in kilometers for the segment and the top number is the code for the nodes.



Segments:

S – 2: “Bole to Bole Medhanialem”
 2 – 3: “Bole Medhiale to Urael”
 3 – 4: “Urael to Cassanchise Total”
 4 – 5: Cassanchise Total to Betemengist”
 5 – t: Betemengist to 6 Kilo

Route One

S – 6: “Bole to Olympia”
 6 – 8: “Olympia to Estifanos”
 7– 5: Estifanos to Betemengist”
 5 – t: Betemengist to 6 Kilo

Route Two

S – 6: “Bole to Olympia”
 6 – 8: “Olympia to Estifanos”
 8 – 9: “Estifanos to Ambassador”
 9-10: “Ambassador to Yedirow Keta”
 10-t: “Yedirow Kera to 6 Kilo”

Route Three

S – 6: “Bole to Olympia”
 6 - 7: “Olympia to Bambis”
 7 – 4: “Bambis to Cassanchise Total”
 4 – 5: Cassanchise Total to Betemengist”
 5 – t: Betemengist to 6 Kilo

Route Four

Steps of Analysis:

We now represent the dynamic programming formulation and outline the algorithm solution. This approach has a distinct advantage of straightforward generation to the problem of finding the second best, third best, in general the Kth best solution in the network.

For d_{ij} the distance between nodes i and j, $d_{jj} = 0$

U_i shortest distance from node i to the terminal node N. $U_N = 0$.

$$U_i^{K+1} = \min_{j \neq i} (d_{ij} + U_j^K + U_i^K), \quad i = 1, 2, \dots, N-1.$$

$$U_N^{K+1} = 0$$

Where, N= Terminal Node

i and j are nodes in the network.

K = number of link, $K = N - 1$

$$U_i = \min_k (U_i^k)$$

$$U_5^1 = 3.1; U_9^1 = 2.8$$

$$U_4^2 = U_5^1 + d_{4,5} = 3.1 + 1.2 = 4.3$$

$$U_8^2 = U_5^1 + d_{8,5} = 3.1 + 2.6 = 5.7$$

$$U_9^2 = U_9^1 + d_{9,10} = 2.8 + 2.5 = 5.3$$

$$U_8^3 = U_9^2 + d_{8,9} = 5.3 + 1.3 = 6.6$$

$$U_6^3 = U_8^2 + d_{6,8} = 5.7 + 1.1 = 6.8$$

$$U_3^3 = U_4^2 + d_{3,4} = 4.3 + 1.4 = 5.7$$

$$U_7^3 = U_4^2 + d_{7,3} = 4.3 + 1.8 = 6.1$$

$$U_{6-8}^4 = U_8^3 + d_{6,8} = 6.6 + 1.1 = 7.7$$

$$U_{6-7}^4 = U_7^3 + d_{6,7} = 6.1 + 0.8 = 6.9$$

$$U_2^4 = U_3^3 + d_{2,3} = 5.7 + 1.2 = 6.9$$

$$U_s^4 = U_6^3 + d_{s,6} = 6.8 + 1.6 = 8.4 \quad \dots \text{Route Three}$$

$$U_s^5 = U_2^4 + d_{s,2} = 6.9 + 0.9 = 7.8 \quad \dots \text{Route One}$$

$$U_s^5 = U_{6-8}^4 + d_{s,6} = 7.7 + 1.6 = 9.3 \quad \dots \text{Route Two}$$

$$U_s^5 = U_{6-7}^4 + d_{s,6} = 6.9 + 1.6 = 7.5 \quad \dots \text{Route Four}$$

$$\text{Min}(U_s^4, U_s^5, U_s^5, U_s^5) = U_s^5 = 7.5 \text{ Km.}$$

The values in the link need not always be the length of the segments. It could be the time taken to cover the segment, the ratio of traffic density to road capacity at each time interval, or the risk on each segment, etc.

Chapter 7

7 Software Development (Route Selection)

7.1. General

The program code is written with the help of visual basic programming language. The analysis of the software follows two major tasks. The first task is to manage the flow of vehicles in the less traffic density path. In this case the risk of each segments are analyzed and the output from the software will be a choice to the user to follow either on the less traffic density path or in a path where the occurred number of accident on the route is minimum. The second alternative is to select shortest path, irrespective of the traffic parameters. The developed software is based on the following theories.

City traffic

This is an environment that visualises a traffic network. In this network vehicles are moving from their starting point to their destination. For the route they follow they can depend on a fixed standard route as well as on a dynamic route provided by the Routing system. On their way the drivers have to deal with realistic traffic features like traffic lights and precedence rules. The vehicles must be enabled to communicate with the Routing system.

Control centre

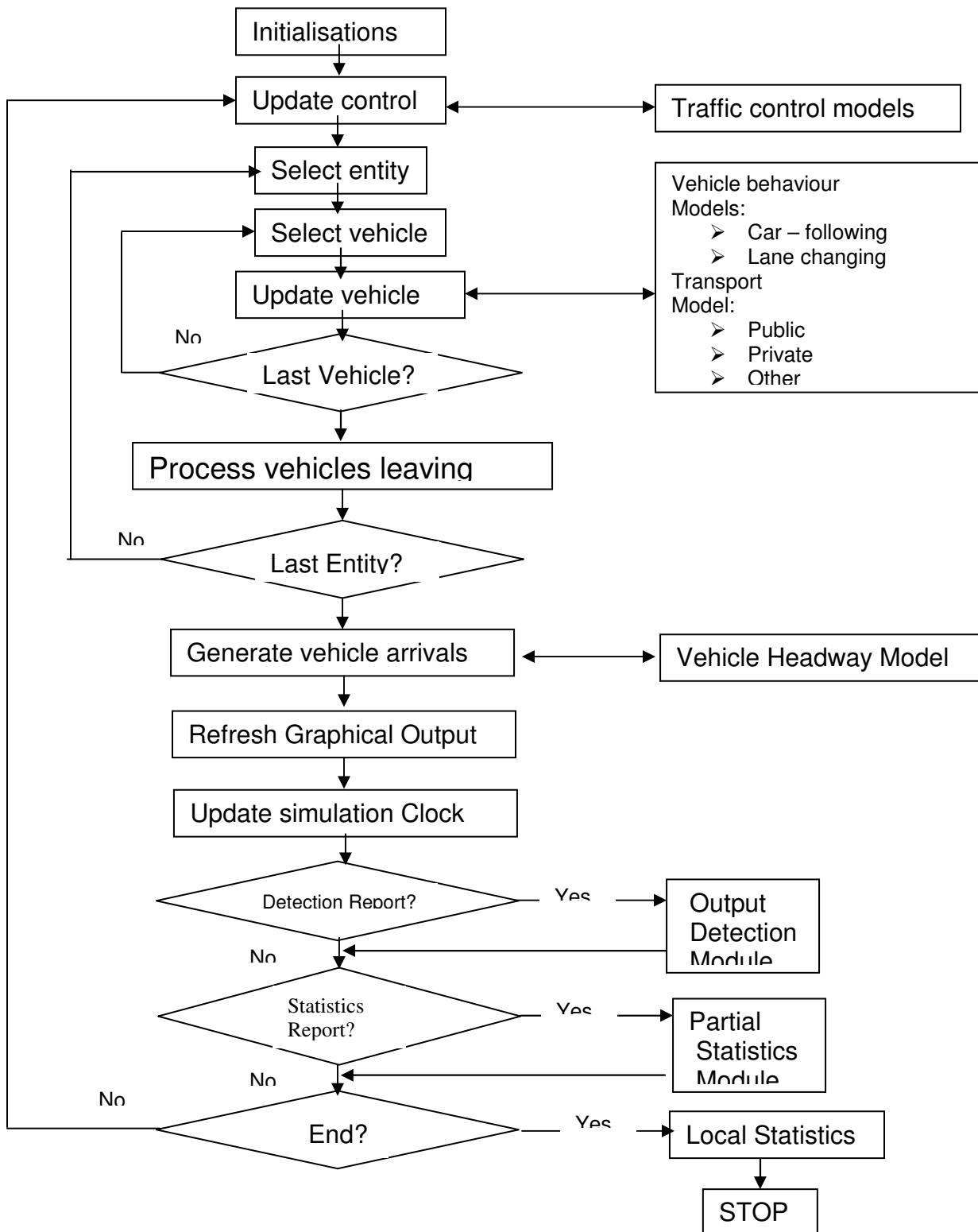
The Control centre is part of the City program. Its function is to enable varying of parameters. This concerns both the simulation of the traffic network as well as the Routing system. It allows for setting the duration of a simulation, and the load of the traffic network. But it also allows for fine-tuning of parameters used by the routing algorithm.

Timetable updating system

The Timetable updating system can receive its information about the traffic network in the city from different sources. Traffic information services can inform the system about congestion – traffic flow density. The vehicles themselves can provide the system with information about the path they followed and the time it took them to cover it. In our model the crossings are the marking points. The traffic flow between the marking points is computed with the information from the dedicated field data collectors. This way the travel time for every route from any crossing to any other crossing (nodes is also used interchangeably) in the route can be computed by just adding up all the traffic density between the marking points to the destination.

7.2 Program flow chart and development

The program for the software flows the flow chart described below.



7.3 Program execution and outputs

To start the program, one has to select user name as “user” so that it allows only to access for the selection of routes, based on the two alternatives.

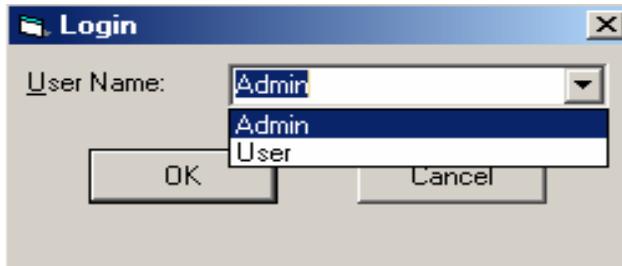


Fig 7.2. Users login.

If the user “Admin” is selected, it will ask for the users name and Password. The admin is the one who will manipulate the data for the program.



Fig 7.3. Admin login.

If the user is “Admin”, and feed the user name and Password, it will ask for the following; to create additional user, to delete or change password.

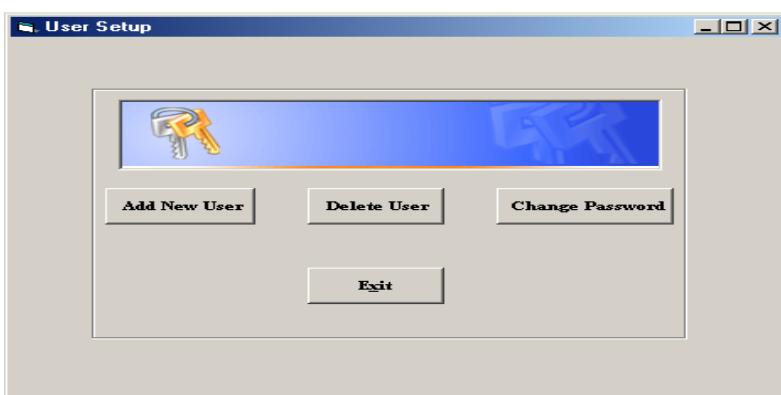


Fig 7.4. New user addition and password management.

Once the user is defined, the interactive window will appear. The user is then expected to scroll from the menu, and select. Figure below indicates these features.

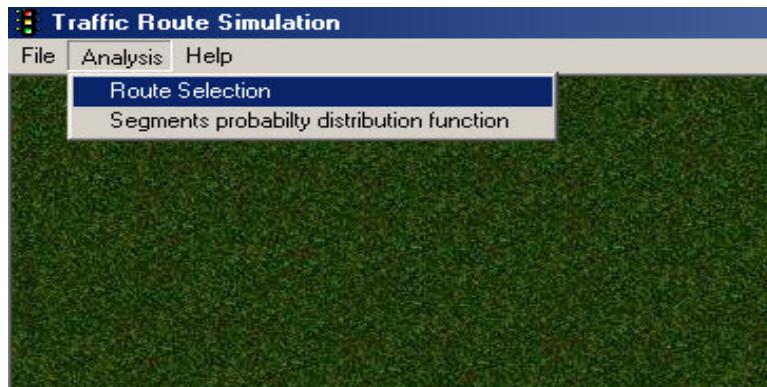


Fig 7.5. User interactive window.

Selection of the route selection menu, the child interface that leads the user again to select for either shortest route or traffic density or risk displayed. There is time range for the output, although it is the same result with respect to shortest distance, it is different for the other selection - Traffic Density and Risk. The user checks one of the criterions and goes to selection for source, Destination and Time of Travel. Finally, the command bottom “Analyze this” have to clicked to see the selected routes. Figure below shows these features.

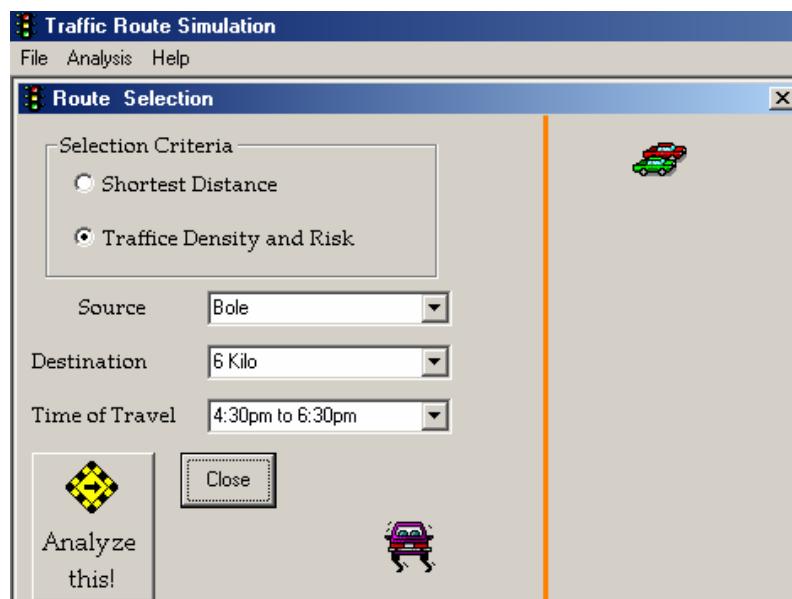


Fig 7.6. Route selection window.



Fig. 7.7. Selected route directing map

The logic of simulation process in the programming is illustrated in figure 7.1 above. It can be considered as hybrid simulation process, combining the event scheduling approach with activity scanning. At each time interval (simulation steps), the cycle updates the unconditional events scheduling lists (i.e., events such traffic density changes). The “update control” box in the flow chart represents this step. After this update process, a set of nested loops starts to update the state of the entries (density at junctions) in the model.

New traffic densities are input into the network according to flow generation procedure (head distribution) at input section. The simulation process includes an initial computation of routes going from every section to every destination according to link shortest distance (list cost assumption) criteria. The flow chart, route based simulation process, shown in this model (additional box shaded maroon on the same flow chart). In this case the shortest route component periodically calculates the new shortest route according to the new travel time, and a route selection assigned during the current time interval. In all the cases the accident rate history of the selected network is assigned with the Monte Carlo simulation technique.

(A) Probability Density function to calculate random numbers:

The Input data, maximum and minimum traffic density for each segment is statistically selected from the time series data, collected on the field. There are twelve data for the first time range (Pick hour One: 7:00 am – 9:00 am), as described in the methodology part. Similarly at 12:00 am – 2:00 pm and 4:00 pm – 12:30 pm, the procedure repeated.

The program accepts these two boundary values and a random numbers are then generated that fall in between. The generated numbers are then again set to another condition, which is to fit with Erlange Probability Distribution function and checked. The target in the random number generation is such that the probability of it being 0.8 as compared to the Erlange distribution function [Appendix I].

$$P(D > D_p) = \sum_{i=0}^K \left[\frac{K D_{gen}}{D_{mean}} \right]^i e^{-\left[\frac{K D_{gen}}{D_{mean}} \right]}$$

Where, $K = \frac{(\bar{x})^2}{S^2}$

D_{mean} = Mean Traffic Density (from Maximum and Minimum inputs)

D_{gen} = Generated Traffic Density

D_p = Generated Traffic Density for $p > 0.8$

Chapter 8

8. Conclusions and Recommendations

The statistical analysis in this study clearly shows that the road traffic accident is at a higher risk. Although the rate of varies from year to year, the cumulative is growth in the number of accident. Furthermore, the property damage estimates, only in Addis Ababa, which were 10 Million ETB in 1996, escalated to 25 Million ETB in the year 2005.

In Addis Ababa roads, there are about 4 fatalities in 5 Days. This means there is, approximately, a chance of 0.8×10^{-6} for an individual to get in to this fatality in Addis Ababa.

This study suggested a method to prediction accidents by considering physical and traffic characteristics of each road. For this, we analyzed road-characteristic causes to accidents of roads and selected road-characteristics causes affected accidents analysing the relations between causes and accidents.

Based on this, we proposed a model to prediction accident-occurring possibilities of those sections according to the physical factors of the roads. The results from accident prediction model developed by selected variables show that in case of two lanes road, the number of intersections, pavement width, degree of curvature and daily traffic volume flow is critical parameters considered. The values compared to accident per road type accident/km suggested by the prediction results and the actual accident record data. Although the results of actual accident record data and the study prediction are different and difficult for direct comparison, as a whole, they have similar results.

However, the study could apply more detailed classification standard and predicted accidents. If might use the result of this research, one could execute safety evaluation about various alternatives in case planning new road business and could calculate results in detail for accidents reduction benefit when survey for validity of road business. This study has a limit to research selected roadways of Addis Ababa City data, which requires

a comprehensive study based on whole citywide accidents documents. And I judge it needs to divide the sites into high, moderate and low areas by the gaps of intersections to the accident predictive model from the start of the planning, so it is expected that some other researchers take part in the study considering the gaps of intersections from now on.

Future development of the thesis may include the routing system, which could help users to find any address in the city. It could also be used to find a free parking place in the centre or near some other address. And more important, it should provide the route with the shortest travel time for the whole network in the city; it avoids congested roads when other roads are faster. It provides short cuts for the user that didn't know the city at all.

The traffic accident data analysis indicates that most of the accidents are caused due to operators' mistake; these errors are behavioral and could be corrected through education and awareness. There are only very few organizations in Addis Ababa that are directly involved in many activities which are targeted to such changes. The world wide accepted measure, "3E: Education, Engineering and Empowering" are widely exercised in the developed nations and resulted a tremendous decrease in road traffic accidents. Therefore, We need to make a behavioral change in the population by engaging most of the organizations in the initiatives towards education.

The fact that in the raining seasons driving activity becomes more difficult, people must have to be transported for the fact of life. In these seasons, traffic accident increases. Therefore, special attentions to the identified black spots have to be given from the authority.

Addis Ababa is the capital city of Ethiopia and the seat of many national and international organizations, like the organization of African unity, the economic commission of Africa, many liberation and aid organizations etc. In addition to this there is a rapid growth of population and increasing number of every sophisticated vehicle, which are creations of up to date technology with every back ward vehicle included. This is more than the capacity of unsuitable road, which are deteriorating unable to carry very

heavy trucks. Over time those problems became more acute under the out dated transport law.

Addis Ababa is suffering as far as road traffic is concerned. Therefore Addis Ababa road traffic problem demands an immediate response from the government, its organs and other concerned institutions. As a result this study will concentrate on traffic accidents in Addis Ababa.

To summarize the main road Safety traffic accident problems in Addis Ababa, the points below are generalized.

- Drivers not respecting pedestrian priority
- Over speeding
- Poor skill and undisciplined behavior of drivers
- Pedestrians not taking proper precautions
- Over loaded or improperly loaded vehicles
- Weak traffic law enforcement
- Lack of proper emergency medical services
- Poor vehicle conditions;

And institutional and process related issues like,

- Weak Institutions & Poor Coordination
- Lack of Political Will
- Laxity in Enforcement
- Poor Emergency and Rescue Services

Recommended driver training and licensing procedures

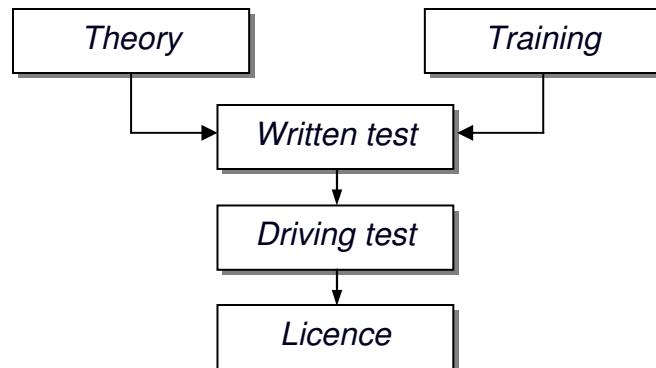


Fig 8.1 Existing driver training and licensing procedure

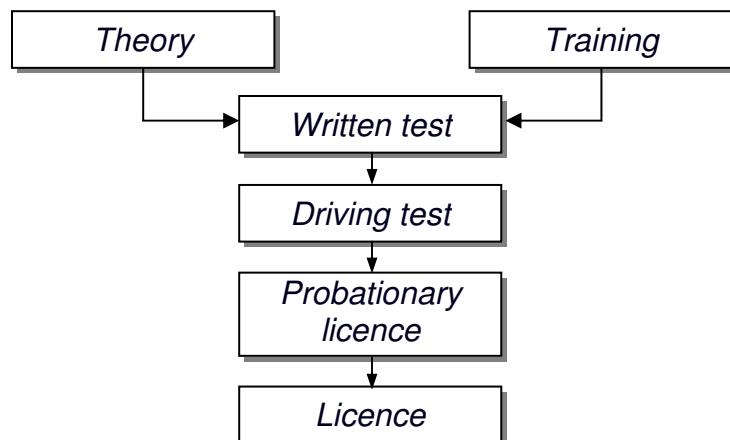


Fig 8.2 Recommended driver training and licensing procedure

The existing driver training and licensing procedure, fig 8.1 above, has a limitation to open a room in the continuous improvements of the drivers' behavior. The license issued is not permanent in the recommended procedure, usually two ears of probationary license. The driver is coached in the probation period and any mistake; incidents committed in this period are recorded for individual's file.

The driver is then issued the full license if there are no as such recordable accidents attached to the drivers file. However, the driver might be denied to get full license for the number or severity of recorded accident committed being exceeds the limits.

The existing theory training includes items that are directly related to the driving activity. In most of the training centers traffic regulations and a brief in vehicle techniques are the two topics covered.

Items to be covered in theory training according to priority are listed below.

1. Traffic regulation
2. Behaviour towards others
3. Vehicle technique
4. The road (hazard perception)
5. The driver (hazard perception)
6. Weather conditions (hazard perception)
7. Environmental friendly driving
8. Others (e.g. first aid)

The points below are the more activities that shall be implemented as it is proved from other low-income nations, to decrease the road traffic accident,

1. Awareness of traffic participants has to be increased
2. Traffic calming principles should be used
3. Stretched target of the Addis Ababa traffic bureau need to be SMART
4. Implement Drink/drive measures
5. Road safety engineering measures
6. Implement road safety audit and engineering measures
7. Establish road safety engineering units in road authorities
8. Implement mandatory vehicle insurance law
9. Implement traffic safety education for children
10. Promote road safety publicity on speed limits and pedestrian priority
11. Improve accident data collection and processing system (Data Management)
12. Implement research on road safety publicity and accident costing
13. Improving the design of roads
14. Strengthening the technical inspection of vehicles
15. Prohibition of use of hand-held mobile telephones while driving
16. Use of seatbelts.

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Appendix A : Factors that result in accident

A: Collisions due to actions of drivers/riders

- 1 Tired or asleep
- 2 Illness
- 3 Drunk or drugged
- 4 Speed too great for prevailing conditions
- 5 Failing to keep to nearside
- 6 Overtaking improperly on nearside
- 7 Overtaking improperly on offside
- 8 Failing to stop at pedestrian crossing
- 9 Turning round carelessly
- 10 Reversing carelessly
- 11 Failing to comply with traffic sign
(other than double white line or traffic lights)
- 12 Failing to comply with double white lines
- 13 Starting from nearside carelessly
- 14 Starting from offside carelessly
- 15 Changing traffic lanes carelessly
- 16 Cyclist riding with head down
- 17 Cyclists more than two abreast
- 18 Turning left carelessly
- 19 Turning right carelessly
- 20 Opening doors carelessly
- 21 Crossing road junction carelessly
- 22 Cyclist holding another vehicle
- 23 Not in use
- 24 Misjudging clearance
- 63 Failing to comply with traffic lights
- 64 Incorrect use of vehicle lighting

B: Collisions due to actions of pedestrians

- 26 Crossing road masked by vehicle
- 27 Walking or standing in road
- 28 Playing in road
- 29 Stepping or running into road carelessly
- 30 Physical defects or illness
- 31 Drunk or drugged
- 32 Holding onto vehicle

C: Vehicle lighting

- 33 Dazzle by other vehicle's lights
- 34 Inadequate rear lights
- 35 Inadequate front lights
- 36 Not in use

D: Collisions due to actions of passengers

- 37 Carelessly boarding or alighting from bus
- 38 Falling inside or from vehicle
- 39 Opening door carelessly
- 40 Negligence by conductor of bus

E: Collisions due to actions of animals

- 41 Dog in carriageway
- 42 Other animal in carriageway

F: Collisions due to obstructions

- 43 Stationary vehicles dangerously placed
- 44 Other obstructions

G: Collisions due to defective vehicles

- 45 Defective brakes
- 46 Defective tyres or wheels
- 47 Defective steering
- 48 Unattended vehicle running away
- 49 Insecure load
- 50 Other defects

H: Collisions due to road conditions

- 51 Pot hole
- 52 Defective manhole cover
- 53 Other road surface conditions
- 54 Road works in progress
- 55 Slippery road surface (not weather)
- 65 Flood

I: Collisions due to weather conditions

- 56 Fog or mist
- 57 Ice, frost or snow
- 58 Strong wind
- 59 Heavy rain
- 60 Glaring sun

J: Collisions due to other factors

61

K: Collisions due to unknown factors

62

USE 61 OR 62 ONLY IF ALL OTHER FACTORS ARE INAPPROPRIATE

Contributory factors.

Appendix A –1: Accident Record sheet 01

Department of Transport

1.1 Record Type	1 2
1 New accident record	<input type="checkbox"/>
5 Amended accident record	<input type="checkbox"/>
1.2 Police Force	3 4
1.3 Accident Ref No.	5 6 7 8 9 10 11
1.4 Severity of Accident	12
1 Fatal 2 Serious 3 Slight	<input type="checkbox"/>
1.5 Number of Vechicles	13 14 15
1.6 Number of Casualty Records	16 17 18
1.7 Date	Day Month Year 19 20 21 22 23 24
1.8 Day of Week	25
1 Sunday 2 Monday 3 Tuesday 4 Wednesday 5 Thursday 6 Friday 7 Saturday	<input type="checkbox"/>
1.9 Time	Hrs Mins 26 27 28 29 24 hour
1.10 Local Authority	30 31 32

Accident Record Attendent Circumstances

1.11 Location 10 digit reference No. 33 34 35 36 37 38 39 40 41 42	STATS19 (Rev 2/91)
Eastng 43 Northing	63
1.12 1st Road class 1 Motorway 2 A (M) 3 A 4 B 5 C 6 Unclassified 7 Local 8 Authority 9 Use only	1.17 Junction Control 1 Authorised person 2 Automatic traffic signal 3 Stop sign 4 Give way sign or markings 5 Uncontrolled
44 45 46 47	54
1.13 1st Road Number	1.18 2nd Road Class 1 Motorway 2 A (M) 3 A 4 B 5 C 6 Unclassified 7 Local 8 Authority 9 Use only
48	55
1.14 Carriageway Type or Markings 1 Roundabout (on circular highway) 2 One way street 3 Dual carriageway – 2 lanes 4 Dual carriageway – 3 or more lanes 5 Single carriageway – single track road 6 Single carriageway – 2 lanes (one each direction) 7 Single carriageway – 3 lanes (two way capacity) 8 Single carriageway – 4 or more lanes (two way capacity) 9 Unknown	1.19 2nd Road Number 56 57 58 59
49 50 51	60 61
1.15 Speed Limit mph	1.20 Pedestrian Crossing Facilities 0 No crossing facilities within 50 metres 1 Zebra 2 Zebra crossing controlled by school crossing patrol 3 Zebra crossing controlled by other authorised person 4 Pelican 5 Other light controlled crossing 6 Other sites controlled by school crossing patrol 7 Other sites controlled by other authorised person 8 Central refuge – no other controls 9 Footbridge or subway
52 53	62
1.16 Junction Detail 0 Not at or within 20 metres of junction 1 Roundabout 2 Mini-roundabout 3 'T' or staggered junction 4 'Y' junction 5 Slip road 6 Crossroads 7 Multiple junction 8 Using private drive or entrance 9 Other junction	1.21 Light Conditions DAYLIGHT 1 Street lights 7 metres or more high 2 Street lights under 7 metres high 3 No street lighting 4 Daylight street lighting unknown DARKNESS 5 Street lights 7 metres or more high (lit) 6 Street lights 7 metres or high (lit) 7 No street lighting 8 Street lights until 9 Darkness street lighting unknown
66	67
1.22 Weather 1 Fine (without high winds) 2 Raining (without high winds) 3 Snowing (without high winds) 4 Fine with high winds 5 Raining with high winds 6 Snowing with high winds 7 Fog (or mist if hazard) 8 Other 9 Unknown	1.23 Road Surface Condition 1 Dry 2 Wet/Damp 3 Snow 4 Frost/Ice 5 Flood (surface water over 3cms (1 inch) deep)
68 69 70 71	1.24 Special Conditions at Site 0 None 1 Automatic Traffic Signal-out 2 Automatic Traffic Signal partially defective 3 Permanent road signing defective or obscured 4 Road works present 5 Road surface defective
1.25 Carriageway Hazards 0 None 1 Dislodged vehicle load in carriageway 2 Other object in carriageway 3 Involvement with previous accident 4 Dog in carriageway 5 Other animal in carriageway	1.26 Overtaking Manoeuvre Patterns No longer required by the Department of transport
1.27 DTp Special Projects 68 69 70 71	

Appendix A –2: Accident Record sheet 02

2.1 Record Type	1 2	2.8 Vehicle Movement	20 21	2.12 Hit Object In	28 27	2.16 First Point of Impact	32
1 New vehicle record	<input type="checkbox"/>	Compass Point	Front To	00 None	<input type="checkbox"/>	0 Did not impact	
5 Amended vehicle record	<input type="checkbox"/>	1 N 2 NE 3 E		01 Previous accident	<input type="checkbox"/>	1 Front	
3 4	<input type="checkbox"/>	4 SE 5 S 6 SW		02 Road works	<input type="checkbox"/>	2 Back	
2.2 Police Force	<input type="checkbox"/>	7 W 8 NW		03 Parked vehicle - lit	<input type="checkbox"/>	3 Offside	
		or	<input type="checkbox"/> <input type="checkbox"/> Parked - not at kerb	04 Parked vehicle - until 05 Bridge (root)	<input type="checkbox"/>	4 Neoside	
2.3 Accident Ref No.	<input type="checkbox"/>		<input type="checkbox"/> <input type="checkbox"/> Parked - at kerb	06 Bridge (side)	<input type="checkbox"/>	33 34 35	
2.4 Vehicle Ref No.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			08 Open door of vehicle	<input type="checkbox"/>	2.17 Other Vehicle Hit	
	<input type="checkbox"/> <input type="checkbox"/>			09 Central island or roundabout	<input type="checkbox"/>	(VEH Ref No.)	
2.5 Type of Vehicle	12 13 14			10 Kerb	<input type="checkbox"/>		
01 Pedal cycle	<input type="checkbox"/>	22 23		11 Other object	<input type="checkbox"/>	2.18 Part(s) Damaged	36 37 38
02 Moped	<input type="checkbox"/>			28	<input type="checkbox"/>	0 None	<input type="checkbox"/>
03 Motor scooter	<input type="checkbox"/>				<input type="checkbox"/>	1 Front	<input type="checkbox"/>
04 Motor cycle	<input type="checkbox"/>				<input type="checkbox"/>	2 Back	<input type="checkbox"/>
05 Combination	<input type="checkbox"/>				<input type="checkbox"/>	3 Offside	<input type="checkbox"/>
06 Invalid Tricycle	<input type="checkbox"/>				<input type="checkbox"/>	4 Neoside	<input type="checkbox"/>
07 Other three-wheeled car	<input type="checkbox"/>				<input type="checkbox"/>	5 Roof	<input type="checkbox"/>
08 Taxi	<input type="checkbox"/>				<input type="checkbox"/>	6 Underside	<input type="checkbox"/>
09 Car (four wheeled)	<input type="checkbox"/>				<input type="checkbox"/>	7 All four sides	<input type="checkbox"/>
10 Minibus/Motor caravan	<input type="checkbox"/>						
11 PSV	<input type="checkbox"/>						
12 Goods not over 1 1/2 tons UNW (1.52 tonnes)	<input type="checkbox"/>						
13 Goods over 1 1/2 tons UNW (>1.52 tonnes)	<input type="checkbox"/>						
14 Other motor vehicle	<input type="checkbox"/>						
15 Other non motor vehicle	<input type="checkbox"/>						
2.6 Towing and Articulation	17						
0 No tow/articulation	<input type="checkbox"/>						
1 Articulated vehicle	<input type="checkbox"/>						
2 Double/multiple trailer	<input type="checkbox"/>						
3 Caravan	<input type="checkbox"/>						
4 Single trailer	<input type="checkbox"/>						
5 Other tow	<input type="checkbox"/>						
2.7 Manoeuvres	18 19						
01 Reversing	<input type="checkbox"/>						
02 Parked	<input type="checkbox"/>						
03 Waiting to go ahead but held up	<input type="checkbox"/>						
04 Stepping	<input type="checkbox"/>						
05 Starting	<input type="checkbox"/>						
06 U turn	<input type="checkbox"/>						
07 Turning left	<input type="checkbox"/>						
08 Waiting to turn left	<input type="checkbox"/>						
09 Turning right	<input type="checkbox"/>						
10 Waiting to turn right	<input type="checkbox"/>						
11 Changing lane to left	<input type="checkbox"/>						
12 Changing lane to right	<input type="checkbox"/>						
13 Overtaking moving vehicle on its offside	<input type="checkbox"/>						
14 Overtaking stationary vehicle on its offside	<input type="checkbox"/>						
15 Overtaking on neoside	<input type="checkbox"/>						
16 Going ahead left hand bend	<input type="checkbox"/>						
17 Going ahead right hand bend	<input type="checkbox"/>						
18 Going ahead other	<input type="checkbox"/>						
2.11 Skidding and overturning	25						
0 No skidding, jackknifing or overturning	<input type="checkbox"/>						
1 Skidded	<input type="checkbox"/>						
2 Skidded and overturned	<input type="checkbox"/>						
3 Jackknifed	<input type="checkbox"/>						
4 Jackknifed and overturned	<input type="checkbox"/>						
5 Overturned	<input type="checkbox"/>						
2.15 Vehicle Prefix/Suffix Letter	31						
Prefix/Suffix letter or one of the following codes:							
0 More than twenty years old (at end of year)	<input type="checkbox"/>						
1 Unknown/cherished number/not applicable	<input type="checkbox"/>						
2 Foreign/diplomatic	<input type="checkbox"/>						
3 Military	<input type="checkbox"/>						
4 Trade plates	<input type="checkbox"/>						
2.24 Hit and Run	46						
0 Other	<input type="checkbox"/>						
1 Hit and run	<input type="checkbox"/>						
2 Non stop vehicle not hit	<input type="checkbox"/>						
2.25 DTP Special Projects	47 48 49 50						

Appendix A –3 : Accident Record sheet 03

3.1 Record Type 1 2 3 <input type="checkbox"/> 4 <input type="checkbox"/> 1 New casualty record 5 Amended casualty record	3.7 Sex of Casualty 19 <input type="checkbox"/> 1 Male 2 Female	3.11 Pedestrian Movement 25 <input type="checkbox"/> 0 Not pedestrian 1 Crossing from drivers nearside 2 Crossing from drivers nearside – masked train by parked or stationary vehicle 3 Crossing from drivers offside 4 Crossing from drivers offside – masked by parked or stationary vehicle 5 In carriageway stationary – not crossing (standing or playing) 6 In carriageway stationary – not crossing (standing or playing) – masked by parked or stationary vehicle 7 Walking along in carriageway facing traffic 8 Walking along in carriageway back to traffic 9 Unknown	3.14 Seat Belt Usage 28 <input type="checkbox"/> 0 Not car or van 1 Safety belt in use 2 Safety belt fitted – not in use 3 Safety belt not fitted 4 Child safety belt/harness fitted – in use 5 Child safety belt/harness fitted – not in use 6 Child safety belt/harness not fitted 7 Unknown
3.2 Police Force 3 <input type="checkbox"/> 4 <input type="checkbox"/>	3.8 Age of Casualty 21 <input type="checkbox"/> (Years estimated if necessary)	3.12 Pedestrian Direction 26 <input type="checkbox"/> Compass point bound 1 N 2 NE 3 E 4 SE 5 S 6 SW 7 W 8 NW or 0 – pedestrian – standing still	3.15 Car Passenger 29 <input type="checkbox"/> 0 Not a car passenger 1 Front seat car passenger 2 Rear seat car passenger
3.3 Accident Ref No. 5 6 7 8 9 10 11 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	3.9 Severity of Casualty 22 <input type="checkbox"/> 1 Fatal 2 Serious 3 Slight	3.10 Pedestrian Location 23 24 <input type="checkbox"/> <input type="checkbox"/> 00 Not pedestrian 01 In carriageway crossing on pedestrian crossing 02 In carriageway crossing within zig-zag lines approach to the crossing 03 In carriageway crossing within zig-zag lines exit the crossing 04 In carriageway crossing elsewhere within 50 metres of pedestrian crossing 05 In carriageway crossing elsewhere 06 On footway or vergo 07 On refuge or central island or reservation 08 In centre of carriageway not on refuge or central island 09 In carriageway not crossing 10 Unknown	3.17 PSV Passenger 30 <input type="checkbox"/> 0 Not a PSV passenger 1 Boarding 2 Alighting 3 Standing passenger 4 Seated passenger
3.4 Vehicle Ref No. 12 13 14 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	3.13 School Pupil Casualty 27 <input type="checkbox"/> 0 Not a school pupil 1 Pupil on journey to/from school 2 Pupil NOT on journey to/from school	3.17 DTp Special Projects 31 32 33 34 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
3.5 Casualty Ref No. 15 16 17 <input type="checkbox"/> <input type="checkbox"/>	3.6 Casualty Class 18 <input type="checkbox"/> 1 Driver or Rider 2 Vehicle or pillion passenger 3 Pedestrian		

Appendix A - 4: Injury road collision Report



Hampshire
Constabulary

T1B 9/93

INJURY ROAD COLLISION REPORTS

Notes for guidance for the completion of road collision reports – T1A
Shaded sections are for computer operator use only

1

ATTENDANT CIRCUMSTANCES

Form Number

If only one form is used, enter 1. For additional forms number consecutively.

Collision Reference Number

To contain Divisional/Section identification letters and collision reference number. No reference to year is required.

Date

Unused boxes to the left of the day or month are to be entered as zeros; thus 9th May 1992 is coded 09 05 92.

Time

Use the 24 hour clock.

Total Number of Casualties/Vehicles

Enter total number of casualties in collision.
 Enter total number of vehicles in collision.

Contributory Factors

Enter up to three factors selected from list overleaf.

Speed Limit

Enter speed limit applicable on the road. Speed limits which are temporarily in force should not be included.

Local Authority

Consult Stats 20, para. 1.10

1st Road Class and Number

Enter the class and number of road on which the collision occurred. If unclassified enter 'U'.

Marker Post Number

Enter kilometres and tenths, using leading zeros as necessary.
 Tenths should be entered in final box.

2nd Road Class and Number

For collisions occurring at junctions only.

Light Conditions

Codes 1–3 apply to daylight collisions.
 Codes 4–7 apply to darkness collisions.

2

CASUALTY DETAILS

Each casualty should be numbered consecutively.
(i.e. 1,2,3 on form 1 and 4,5,6 on form 2, etc.)

Vehicle Reference Number

To identify the vehicle occupied by a casualty prior to the collision.

Pedestrian casualty records should quote the vehicle reference number of the vehicle by which the pedestrian is first hit.

Casualty Severity

Fatal injury includes only those cases where death occurs in less than 30 days as a result of the collision. Fatal does not include death from natural causes or suicide.

Serious injury – examples include: fracture, internal injury, severe cuts and lacerations, crushing, concussion, severe general shock requiring hospital treatment, detention in hospital as an in-patient and injuries to casualties who die 30 or more days after the collision.

Slight injury – examples include: sprains, bruises, cuts judged not to be severe, slight shock requiring road side attention.

Car Passenger

In case of drivers, tick '0 – not car passenger.'

DoT Special Projects Local Special Projects

Use only when directed.

School Pupil

Tick box 1 *only* if the casualty is a school pupil on the journey to or from school. All other casualties, including school age children *not* going to or from school, tick box 0.

School pupils are children aged between 5 and 15 years inclusive.

NB

*First row or column refers to the first casualty/vehicle on form.
 Second row or column refers to second casualty/vehicle on form.
 Third row or column refers to third casualty/vehicle on form.*

3

VEHICLE DETAILS

Vehicle Reference Number

Each vehicle is to be numbered consecutively (i.e. 1,2,3 on form 1 and 4,5,6 on form 2, etc.)

Type of Vehicle

The following types of vehicle are defined:

- Box 8 – Taxi – any licensed hackney vehicle carrying appropriate local authority plates; but does not include private hire vehicles.
- Box 11 – Bus or Coach – any passenger carrying vehicle (PVC) equipped to carry 17 or more persons.
- Boxes 12 and 13 – goods vehicles are classified here by maximum gross weight; either up to and including 3.5 tonnes or over 3.5 tonnes.

Postcode

Give first half of postcode of driver's home address, if known, e.g. if code is S022 5DB enter S022. Part code, e.g. SP is acceptable if remainder is not known. Do not guess if code is known.

Other Vehicle Hit

Enter the vehicle reference number of the first other vehicle (if any) with which the vehicle being coded collided.

DoT Special Projects Local Special Projects

Use only when directed.

Overshoot/Restart

Indicate whether vehicle stopped and restarted at junction (restart) or failed to stop at junction (overshoot).

Part(s) Damaged

Up to three codes may be ticked in this section for each vehicle.

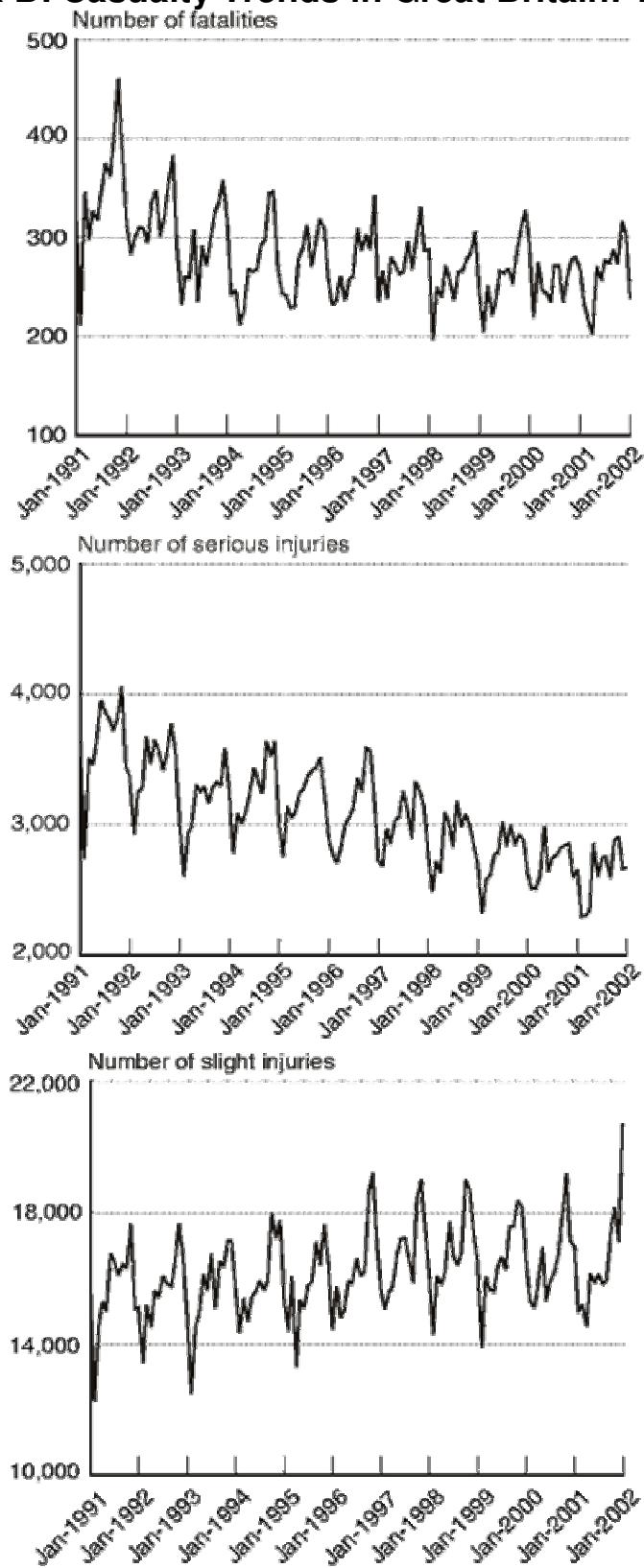
Breath Test

In cases where the breathalyser procedure cannot in law be applied, e.g. in the case of non-motor vehicles, tick '0 – not applicable.'

Where a negative breath test has been given T28A *must* also be submitted.

Example of an injury road collision report.

Appendix B: Casualty Trends in Great Britain: 1991-2002



Appendix c: Junction Types

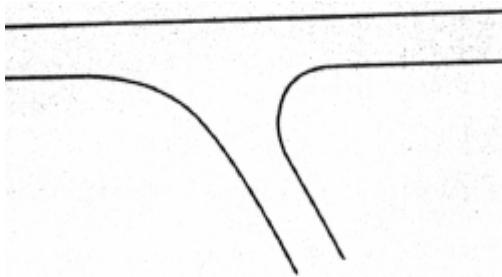


Fig A1. Uncontrolled non-priority junction

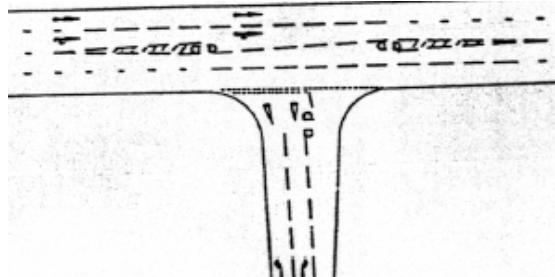


Fig A2 Priority junction

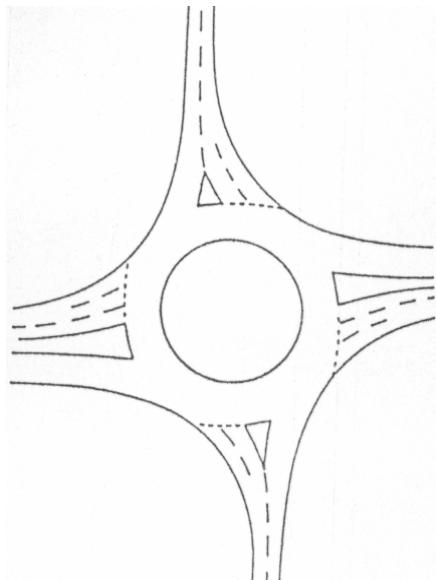


Fig A3. Roundabout

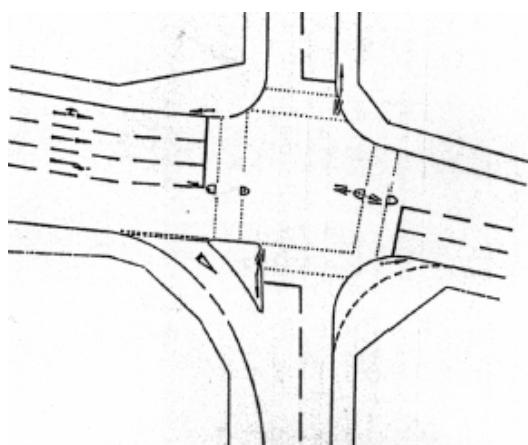


Fig A4. Traffic Signal

Appendix D: Motor Vehicle traffic accident in Ethiopia

Table 1: Total number of accidents - severity

YEAR	TOTAL NUMBER OF ACCIDENTS				TOTAL
	LIGHT	HEAVY	FATAL	PROPERTY DAMAGE	
2000/01	2,134	1,697	1,261	6,684	11,776
2001/02	2,196	1,712	1,327	7,188	12,423
2002/03	2,365	1,790	1,510	8,563	14,228
2003/04	2,705	2,072	1,630	10,569	16,976
2004/05	2,731	2,368	1,801	10,822	17,722

Table 2: Total number of accidents – Fatality by age group

YEAR	NUMBER OF DEATHS			TOTAL
	YOUNG	MATURED	OLD	
2000/01	934	472	154	1,560
2001/02	951	477	199	1,627
2002/03	1,124	487	203	1,814
2003/04	1,293	370	248	1,911
2004/05	1,290	678	220	2,188

Table 2: Total number of accidents – Injured by age group

YEAR	NUMBER OF PERSONS INJURED			TOTAL
	YOUNG	MATURED	OLD	
2000/01	4,077	1,769	541	6,387
2001/02	4,309	1,750	543	6,602
2002/03	4,491	1,898	627	7,016
2003/04	4,625	2,372	880	7,877
2004/05	1,290	678	220	2,188

YEAR ENDING JULY 7
SOURCE :- FEDERAL POLICE CENTRAL BUREAU

Appendix E : Motor Vehicle Traffic Accident in Addis Ababa

Table 1: Total number of accidents

YEAR	LIGHT	HEAVY	FATAL	PROPERTY DAMAGE	TOTAL
	NUMBER OF ACCIDENTS				
2000/01	1,347	499	268	5,089	7,203
2001/02	1,309	532	269	5,512	7,622
2002/03	1,360	528	319	6,429	8,636
2003/04	1,518	589	312	8,048	10,467
2004/05	1,381	731	320	8,111	10,543

Table 1: number of Fatality and injured – grouped by age

YEAR	YOUNG	MATURED**	OLD	TOTAL	YOUNG	MATURED**	OLD	TOTAL
	NUMBER OF DEATHS				NUMBER OF PERSONS INJURED			
2000/01	154	90	46	290	1,411	594	266	2,271
2001/02	112	105	70	287	1,401	555	255	2,211
2002/03	186	82	57	325	1,364	569	307	2,240
2003/04	174	103	68	345	1,661	623	319	2,603
2004/05	172	101	72	345	1,639	666	283	2,588

YEAR ENDING JULY 7

** 31 - 50 YEARS OF AGE

NOTE: LIGHT - OUTGOING PATIENT; HEAVY - IN PATIENT.

HOWEVER THE DEGREE OF INJURY, i.e., LIGHT AND HEAVY IS DETERMINED
BY THE PHYSICIAN WHO HAS EXAMINED THE VICTIMS OF THE ACCIDENT

SOURCE :- FEDERAL POLICE CENTRAL BUREAU

Appendix F: Accident Record Data:

Traffic Accident Statistics - By Date											YTD - 2005
Date	Year										SUM
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
Monday	908	1049	1287	1057	1042	1061	1139	1355	1542	1734	12174
Tuesday	902	1038	1240	1070	1052	1070	1185	1305	1541	1607	12010
Wednesday	882	981	1296	1026	1065	1058	1096	1229	1451	1498	11582
Thursday	940	977	1172	1145	1112	1072	1180	1245	1605	1547	11995
Friday	896	1055	1305	1073	1148	1113	1085	1312	1571	1532	12090
Saturday	957	972	1288	1091	1059	1068	1142	1278	1481	1540	11876
Sunday	717	780	993	883	815	761	795	912	998	1085	8739
Total	6202	6852	8581	7345	7293	7203	7622	8636	10189	10543	80466

Source: Federal Police Central Bureau

Appendix G: Accident Record Data:

Date	Traffic Accident Statistics - By Time										Total
	Year										
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
0100 - 0200	51	44	54	51	60	63	50	76	69	92	610
0200 - 0300	47	21	36	43	54	33	48	64	79	76	501
0300 - 0400	28	23	36	34	36	29	45	49	58	82	420
0400 - 0500	12	25	38	31	24	32	34	37	65	57	355
0500 - 0600	63	75	72	78	57	59	67	90	98	86	745
0600 - 0700	161	181	232	191	180	167	158	222	228	171	1891
0700 - 0800	380	442	566	461	485	432	428	535	528	345	4602
0800 - 0900	435	497	583	517	540	484	591	673	763	710	5793
0900 - 1000	433	488	602	517	475	523	585	624	699	785	5731
1000 - 1100	395	442	617	478	463	515	582	670	746	770	5678
1100 - 1200	407	459	648	481	531	518	567	616	754	814	5795
1200 - 1300	380	425	479	402	407	465	512	533	639	759	5001
1300 - 1400	373	397	485	432	434	433	425	531	558	623	4691
1400 - 1500	342	447	548	509	479	459	447	535	687	605	5058
1500 - 1600	453	504	589	494	492	532	518	581	680	673	5516
1600 - 1700	450	504	593	561	488	453	483	590	685	679	5486
1700 - 1800	443	457	573	471	478	428	476	568	639	657	5190
1800 - 1900	301	335	429	339	330	352	357	396	530	688	4057
1900 - 2000	344	385	457	390	385	401	346	390	499	499	4096
2000 - 2100	239	245	297	286	263	287	312	287	422	484	3122
2100 - 2200	173	157	226	216	250	206	230	204	293	355	2310
2200 - 2300	123	121	190	179	156	162	168	158	218	221	1696
2300 - 2400	104	123	140	95	121	100	109	120	148	162	1222
2400 - 0100	65	55	91	89	105	70	84	87	104	150	900
Total	6202	6852	8581	7345	7293	7203	7622	8636	10189	10543	80466

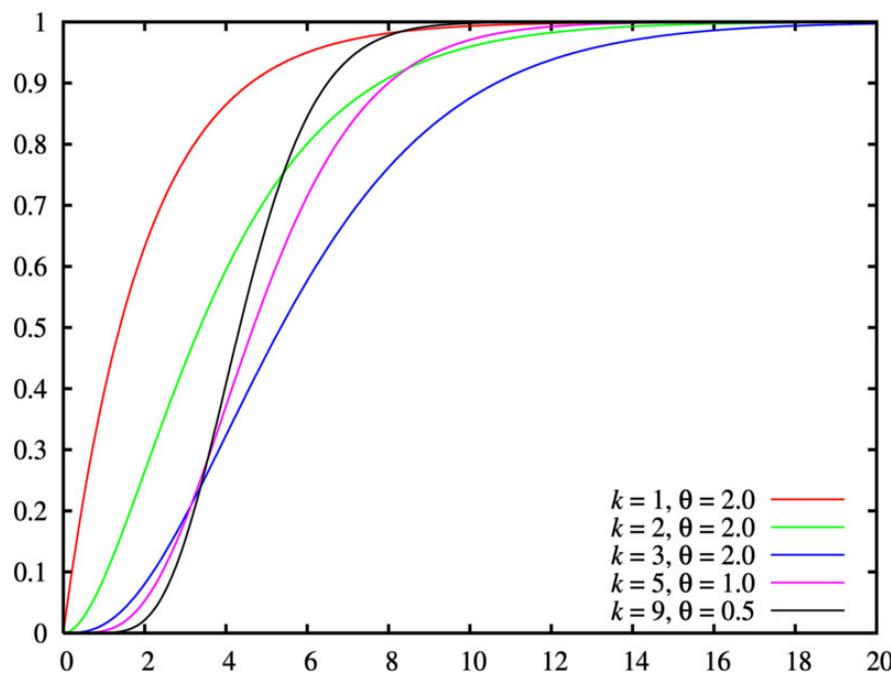
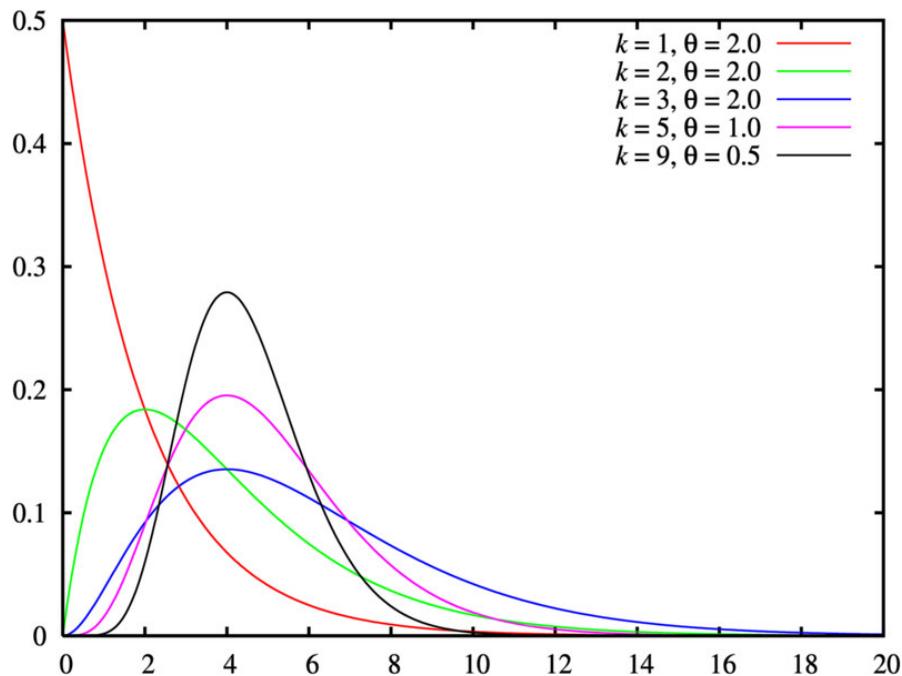
Source: Federal Police Central Bureau

Appendix H : Accident Contributory Factors

Item No.	Attributes of Accident	Total	cumulative	Cum. %
1	Over loading	2559301	2559301	18%
2	Parking on restricted site	1944452	4503753	32%
3	Parking on turnings	887260	5391013	38%
4	Parking at override position	605003	5996016	43%
5	Parking at bus stops	594043	6590059	47%
6	No annual inspection	500094	7090153	51%
7	Incomplete vehicle lighting	468191	7558344	54%
8	Driving vehicle not in license category	426017	7984361	57%
9	Wrong signing	413005	8397366	60%
10	Neglecting traffic light at red indication	346044	8743410	62%
11	Parking on vehicle entrance path	337889	9081299	65%
12	Expired driving license, not updated	304061	9385360	67%
13	Neglecting traffic police instruction	302933	9688293	69%
14	Improper reverse driving	294490	9982783	71%
15	Washing a vehicle on road site	282037	10264820	73%
16	Driving license not at hand	280881	10545701	75%
17	Defected vehicle driving	267027	10812728	77%
18	Neglecting prohibitory traffic signs	240520	11053248	79%
19	Parking on pedestrian crossing	239686	11292934	81%

Source: Federal Police Central Bureau

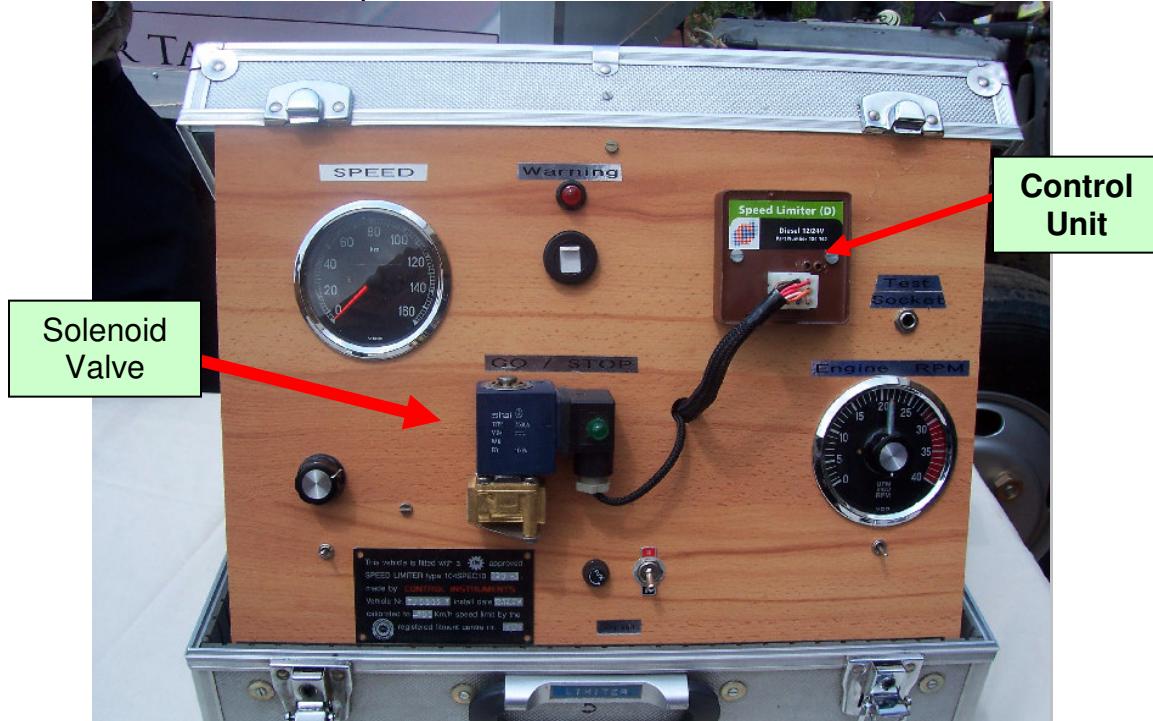
Appendix I : Erlange Distribution Function



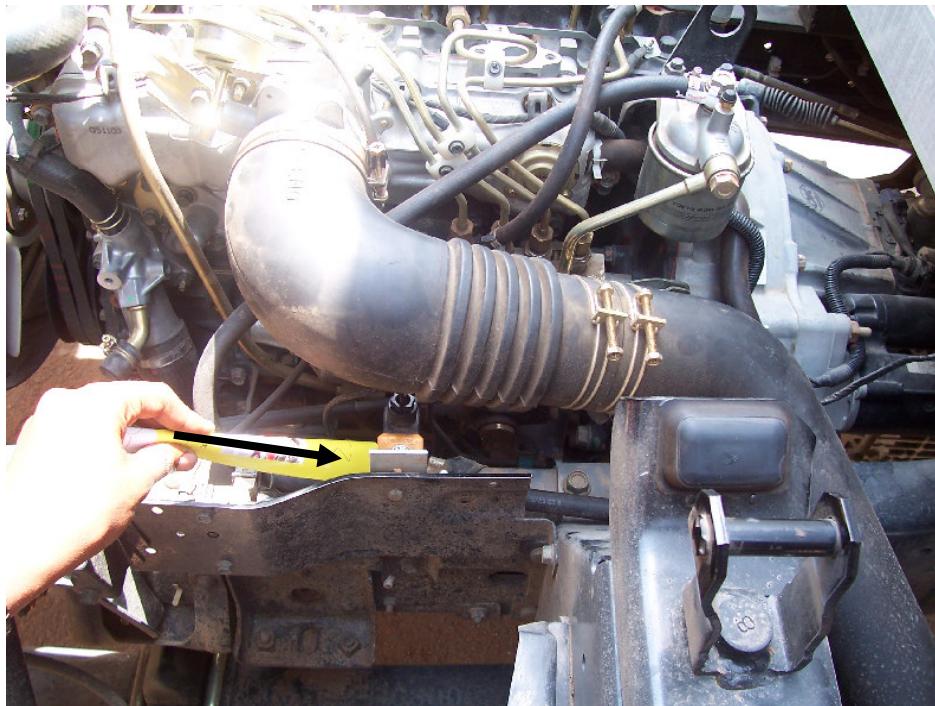
$$\begin{aligned}
 D(x) &= 1 - \sum_{k=0}^{k-1} e^{-\lambda x} \frac{(\lambda x)^k}{\Gamma(k)} \\
 &= 1 - \frac{\Gamma(k, x\lambda)}{\Gamma(k)}
 \end{aligned}$$

Appendix J : Speed Control Device

Speed Limit Solenoids Valve



Solenoid Valve assembled

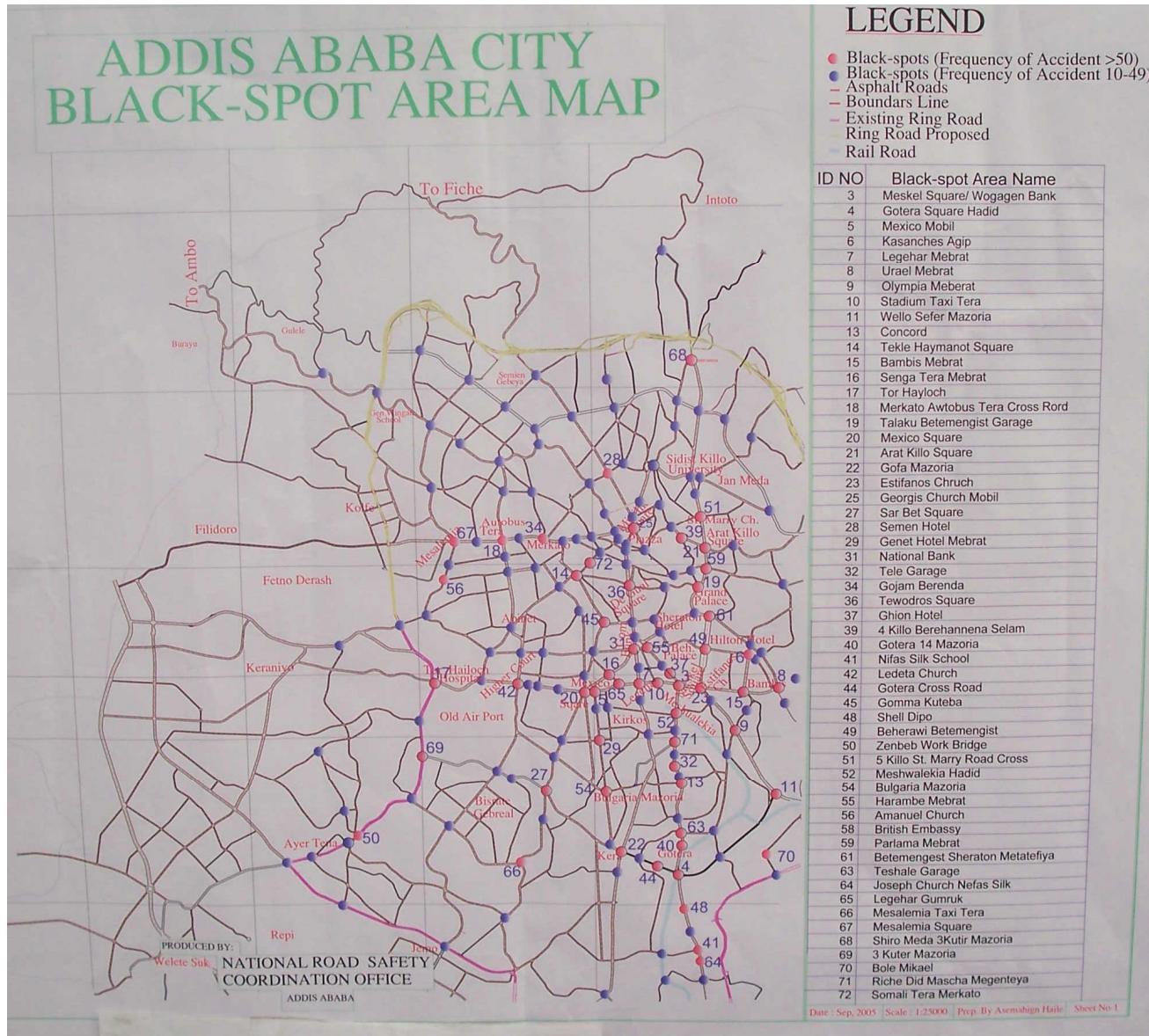


Appendix K : Data Collection Phase

Data Collection phase at Addis Ababa Traffic police Bureau



Appendix L : Black Spot



Black – Spots identified for the Addis Ababa City. This is one of the top activities accomplished by the national road Safety Coordination Office, where Addis Ababa Traffic Police Bureau and Federal Road Transport Authority are main source of information.

Accident in this context is mean fatality only. On the figure the red spots represents frequency of accident greater than 50 and the blue spot – 10 to 49.

Appendix M: Activities that contribute for accident minimization

Future Driving License: [Bar-coded - not easily adopted by illegal]



Speed Control Radars [six additional equipment purchased]



Indicatives for public awareness [Student Traffic on s the show]



June 1 to June 16 every year, there is a national Traffic day, where different activities are performed on the ceremony. The main targets of such activities are to engage the public and increase their awareness about road safety. There are also a few organizations that take part in the road transport safety and public awareness initiatives. Shell Ethiopia Limited is one of them where a dedicated department to deal about Health Safety, Security and Environment in which road safety as one major part of the objectives.

Appendix N: Collected Pictures (PHASE OF THE PROJECT)

Head on collisions [Cause of accident: unknown]



Head on Collision [Cause of accident: Driver engaged on his mobile phone]



Freight truck, "ISUZU", model changed to public transportation bus



Road barrier covered: [possible cause of collision]



A big ditch in the middle of the road



Poor road condition [vehicles forced to use pedestrians' pathway [cause to pedestrians' accident]



Downhill side of the road, frequent accident happens



One of the accidents at the road shown on the above picture



Annex: 1 – VB Code Script

Visual Basic Code Script

Contents

- A. PROGRAM SPLASH CODE 144**
- B. CHOICE FOR USER OR ADMINISTRATOR LOGIN CODE 145**
- C. ADMINISTRATOR LOGIN CODE 146**
- D. ADMINISTRATOR'S SETUP CODE 146**
- E. CALL MAP CODE 153**
- F. SEGMENT DATA UP-DATE CODE 153**
- H. ROUTE DATA UP-DATE CODE 156**
- I. MAP DIRECTION INDICATORS CODE 158**
- J. MAIN PROGRAM CODE 160**

A. Program Splash Code

```
Option Explicit
Private Sub Form_KeyPress(KeyAscii As Integer)
    Unload Me
End Sub

Private Sub Form_Load()
    lblVersion.Caption = "Version " & App.Major & "." & App.Minor & "." &
    App.Revision
    lblProductName.Caption = App.Title
End Sub

Private Sub Frame1_Click()
    Unload Me
End Sub

Private Sub Timer1_Timer()
    frmLogin.Show
    Unload Me
End Sub

Private Sub Timer2_Timer()
    Image7.Top = Image7.Top + 30
    Image9.Top = Image9.Top + 50
    Image10.Top = Image10.Top + 25
    Image11.Top = Image11.Top + 40
    Image12.Top = Image12.Top + 45
    Image13.Top = Image13.Top + 40
    Image14.Top = Image14.Top + 36
    If Image7.Top > 7000 Then
        Image7.Top = 2000
    End If
    If Image9.Top > 5000 Then
        Image9.Top = 2000
    End If
    If Image10.Top > 5000 Then
        Image10.Top = 2000
    End If
    If Image11.Top > 8000 Then
        Image11.Top = 2000
    End If
    If Image12.Top > 9000 Then
        Image12.Top = 2000
    End If
    If Image13.Top > 8123 Then
```

```
    Image13.Top = 2000
End If
If Image14.Top > 5234 Then
    Image14.Top = 2000
End If
End Sub
```

B. Choice for User or Administrator login code

Option Explicit

Public LoginSucceeded As Boolean

```
Private Sub cmdCancel_Click()
    'set the global var to false
    'to denote a failed login
    LoginSucceeded = False
    Unload Me
    'Me.Hide
End Sub
```

```
Private Sub cmdOK_Click()
    'check for correct password
    'If (txtPassword = "password") And (CmbUserName.Text = "Admin") Then
        ' LoginSucceeded = True
        ' Unload Me
        'MDIfrmMain.Show
    'ElseIf (CmbUserName.Text = "User") Then
        If (CmbUserName.Text = "User") Then
            Unload Me
            MDIfrmMain.Show
            MDIfrmMain.mnuAdd.Enabled = False
        Else
            'MsgBox "Invalid Password, try again!", , "Login"
            'txtPassword.SetFocus
            'SendKeys "{Home}+{End}"
            Unload Me
            frmadminlogin.Show
        End If
    End Sub
```

C. Administrator login code

```
Private Sub Command1_Click()
    If Text1.Text = "" Then MsgBox "Enter User Name", vbInformation, "Login": Exit
    Sub
        If Text2.Text = "" Then MsgBox "Enter Password", vbInformation, "Login": Exit
        Sub

        If UCase(Text1.Text) = "FAN" And UCase(Text2.Text) = "TSE" Then
            Setups.Show
            Unload Me
        Else
            MsgBox "Invalid User name / Password", vbExclamation, "Login"
            Text1.Text = ""
            Text2.Text = ""
            Text1.SetFocus
        End If
    End Sub

    Private Sub Command2_Click()
        Unload Me
    End Sub

    Private Sub Text2_KeyUp(KeyCode As Integer, Shift As Integer)
        If KeyCode = 13 Then Call Command1_Click
    End Sub
```

D. Administrator's Setup code

```
Dim cn As New ADODB.Connection
Dim rs As New ADODB.Recordset
```

```
Private Sub Command10_Click()
    'Change password button
    Dim ms As Integer
    cn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=C:\Documents and
    Settings\letfsa0\My Documents\Developed - mee\data\demo --
    mee\USERS.mdb;Persist
    Security Info=False"
    If Combo2.Text = "" Then MsgBox "Select User name", vbInformation, "Password
    change": Exit Sub
```

```
ms = MsgBox("Do you want really Change Password ? " &
Trim(UCase(Combo2.Text)) & "", vbQuestion + vbYesNo, "Password chang")

If Text6.Text = "" Or Text7.Text = "" Then MsgBox "Enter New Password.",,
vbInformation, "Change Password"
Text6.SetFocus

If Trim(Text6.Text) <> Trim(Text7.Text) Then
    MsgBox "Password and Confirm Password are not matched.", vbInformation,
"Confirm Password"
    Text6.Text = ""
    Text7.Text = ""
    Text6.SetFocus
End If

If ms = vbYes Then
    Set rs = New ADODB.Recordset
    rs.Open "select * from USERS where user_name ='" &
    Trim(UCase(Combo2.Text)) & "'", cn, 1, 2
    rs!user_pwd = Text6.Text
    rs.Update

    Text6.Text = ""
    Text7.Text = ""
End If
End Sub
```

```
Private Sub Command11_Click()
    Frame5.Visible = True
    Frame3.Visible = False
End Sub
```

```
Private Sub Command12_Click()
    'Password change ok button
    If Combo2.Text = "" Then MsgBox "Select User Name", vbInformation, "Password
    Change": Exit Sub
    If Text6.Text = "" Then MsgBox "Enter Password", vbInformation, "Password
    Change": Exit Sub
    If Text7.Text = "" Then MsgBox "Enter Confirm Password", vbInformation,
    "PasswordChange": Exit Sub

    If Trim(Text6.Text) <> Trim(Text7.Text) Then
        MsgBox "Password and Confirm Password are not matched.", vbInformation,
"Confirm Password"
        Text6.Text = "
```

```
Text7.Text = ""
Text6.SetFocus
Else
    MsgBox "Your Password Sucessfully Changed", vbInformation, "Password
    Changed"
End If

Set rs = New ADODB.Recordset
rs.Open "select * from USERS where user_name =" &
Trim(UCase(Combo2.Text))
& "", cn, 1, 2
rs!user_pwd = Text6.Text
rs.Update
Text6.Text = ""
Text7.Text = ""
Exit Sub
End Sub
```

```
Private Sub Command2_Click()
'Delete user frame5
    Combo1.Clear
    Set rs = New ADODB.Recordset
    rs.Open "select * from USERS order by user_name", cn, 1, 2
If rs.RecordCount <> 0 Then
    If rs.EOF = True Then rs.MoveFirst

        Do Until rs.EOF

            Combo1.AddItem Trim(rs!user_name)
            rs.MoveNext
        Loop
End If
    Frame2.Visible = True
    Frame1.Visible = False
    Frame3.Visible = False
    'Frame4.Visible = False
    Frame5.Visible = False
End Sub
```

```
Private Sub Command3_Click()
'Change password frame 5
    Combo2.Clear
    Set rs = New ADODB.Recordset
    cn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data
    Source=C:\Documents and
    Settings\etfsa0\My Documents\Developed - mee\datademo --
```

```
mee\USERS.mdb;Persist
    Security Info=False"
    'rs.ActiveConnection = cn
    'rs.Source = "Select * from USERS"
    'rs.Open
    rs.Open "select * from USERS order by user_name", cn, 1, 2

    If rs.RecordCount <> 0 Then

        If rs.EOF = True Then rs.MoveFirst

            Do Until rs.EOF

                Combo2.AddItem Trim(rs!user_name)
                rs.MoveNext
            Loop
        End If

        Frame3.Visible = True
        Frame1.Visible = False
        Frame2.Visible = False
        'Frame4.Visible = False
        Frame5.Visible = False

    End Sub
```

```
Private Sub Command5_Click()
    End
End Sub
```

```
Private Sub Command4_Click()
    Unload Me
    MDIfrmMain.Show
End Sub
```

```
Private Sub Command6_Click()
    'New user ok button
```

```
If Text1.Text = "" Then MsgBox "Enter User name", vbInformation, "New User": Exit Sub
```

```
    If Text2.Text = "" Then MsgBox "Enter Password", vbInformation, "New User": Exit Sub
    If Text3.Text = "" Then MsgBox "Enter Confirm Password", vbInformation, "New User": Exit Sub
```

```
        'chking if password and conform are not same
        If Trim(Text2.Text) <> Trim(Text3.Text) Then
```

```
    MsgBox "Password and Confirm Password are not matched.",  
    vbInformation,  
    "Confirm Password"  
    Text2.Text = ""  
    Text3.Text = ""  
    Exit Sub  
  
End If  
Set rs = New ADODB.Recordset  
cn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=C:\Documents  
and Settings\etfsa0\My Documents\Developed - mee\data demo -  
mee\USERS.mdb;Persist  
Security Info=False"  
rs.ActiveConnection = cn  
rs.Open "select * from USERS where user_name ='" &  
UCase(Trim(Text1.Text)) & "'", cn, 1, 2  
  
'cheiking user name already exit or not  
If rs.RecordCount <> 0 Then  
    MsgBox "Already there is a user name with '" &  
UCase(Trim(Text1.Text)) & "' .",  
vbExclamation, "New User"  
    Text1.Text = ""  
    Text2.Text = ""  
    Text3.Text = ""  
    Exit Sub  
End If  
rs.AddNew  
rs!user_name = UCase(Text1.Text)  
rs!user_pwd = UCase(Text2.Text)  
MsgBox " New User Added", vbInformation  
rs.Update  
Text1.Text = ""  
Text2.Text = ""  
Text3.Text = ""  
Text1.SetFocus  
End Sub  


---

  
Private Sub Command7_Click()  
    Frame5.Visible = True  
    Frame1.Visible = False  
End Sub  


---

  
Private Sub Command8_Click()  
Dim ms As String  
    'DELETE
```

```
If Combo1.Text = "" Then MsgBox "Select User name", vbInformation, "Delete":  
Exit Sub  
    Set rs = New ADODB.Recordset  
    ms = MsgBox("Do you want really delete this User ? " &  
        Trim(UCase(Combo1.Text)) & ".", vbQuestion + vbYesNo, "Delete")  
  
    If ms = vbYes Then  
        Set rs = New ADODB.Recordset  
  
        rs.Open "delete from USERS where user_name= " & Trim(Combo1.Text) & "",  
            cn, 1, 2  
  
        MsgBox " User Deleted", vbInformation, "Deleted"  
        Combo1.Clear  
        'combo1  
        Set rs = New ADODB.Recordset  
        rs.Open "SELECT * FROM USERS ORDER BY user_name", cn, 1, 2  
  
    If rs.RecordCount <> 0 Then  
  
        If rs.EOF = True Then rs.MoveFirst  
  
            Do Until rs.EOF  
                Combo1.AddItem Trim(rs!user_name)  
                rs.MoveNext  
            Loop  
  
        End If  
    End If  
  
End Sub
```

```
Private Sub Command9_Click()  
    Frame2.Visible = False  
    Frame5.Visible = True  
End Sub
```

```
Private Sub Form_Load()  
    Set cn = New ADODB.Connection  
    'cn.Open "dsn=USERS;userid=;pwd=;"  
  
End Sub
```

```
Private Sub Command1_Click()
```

```
Frame1.Visible = True  
Frame2.Visible = False  
Frame3.Visible = False  
'Frame4.Visible = False  
Frame5.Visible = False  
End Sub
```

```
Private Sub Text1_KeyUp(KeyCode As Integer, Shift As Integer)  
    If KeyCode = 13 Then Text2.SetFocus  
End Sub
```

```
Private Sub Text2_KeyUp(KeyCode As Integer, Shift As Integer)  
    If KeyCode = 13 Then Text3.SetFocus  
End Sub
```

```
Private Sub Text3_KeyUp(KeyCode As Integer, Shift As Integer)  
    If KeyCode = 13 Then Command6.SetFocus  
End Sub
```

```
Private Sub Text4_KeyUp(KeyCode As Integer, Shift As Integer)  
    If KeyCode = 13 Then Text5.SetFocus  
End Sub
```

```
Private Sub Text5_KeyUp(KeyCode As Integer, Shift As Integer)  
    If KeyCode = 13 Then Call Command4_Click  
End Sub  
'If KeyCode = 13 Then Command4.SetFocus  
'End Sub
```

```
Private Sub Text6_KeyUp(KeyCode As Integer, Shift As Integer)  
If KeyCode = 13 Then Text7.SetFocus  
End Sub
```

```
Private Sub Text7_KeyUp(KeyCode As Integer, Shift As Integer)  
If KeyCode = 13 Then Command10.SetFocus  
End Sub
```

```
Private Sub Combo2_KeyUp(KeyCode As Integer, Shift As Integer)  
    If KeyCode = 13 Then Text6.SetFocus  
End Sub
```

E. Call Map code

```
Private Sub mnuAbout_Click()
    frmAbout.Show
End Sub
```

```
Private Sub mnuExit_Click()
    Dim reply As String
    reply = MsgBox("Do you really want to quit?", vbInformation + vbYesNo, "Quiting")
    If reply = vbYes Then
        Unload Me
    End If
End Sub
```

```
Private Sub mnupdf_Click()
    frmpdf.Show
End Sub
```

```
Private Sub mnuRouteS_Click()
    frmRoutes.Show
End Sub
```

```
Private Sub mnuRouteSel_Click()
    frmMain.Show
End Sub
```

```
Private Sub mnuSegments_Click()
    frmSegments.Show
End Sub
```

F. Segment Data Up-date code

```
Option Explicit
Dim cn As New ADODB.Connection
Dim rs As ADODB.Recordset
Dim rsSegA As ADODB.Recordset
Dim rsSegB As ADODB.Recordset
Dim rsSegC As ADODB.Recordset
```

```
Private Sub cmdAdd_Click()
    If cmbTime_Travel.Text = "7:00am to 9:00am" Then
        'Segment Infromation Entry
        Set rsSegA = New ADODB.Recordset
        rsSegA.CursorType = adOpenKeyset
        rsSegA.LockType = adLockOptimistic
        rsSegA.Source = "Segments_TimeA"
```

```
rsSegA.ActiveConnection = cn
rsSegA.Open
rsSegA.AddNew
rsSegA.Fields("RouteId") = cmbRouteID.Text
rsSegA.Fields("SegID") = txtSegId.Text
rsSegA.Fields("segDistance") = txtSegDist.Text
rsSegA.Fields("SegK") = txtSegK.Text
rsSegA.Fields("minDensity") = txtSegMinDens.Text
rsSegA.Fields("MaxDensity") = txtSegMaxDens.Text
rsSegA.Fields("segRisk") = TxtSegRisk.Text
rsSegA.Update
'MsgBox rs.RecordCount
'rsSeg.Close
'rs.Close
'cn.Close

ElseIf cmbTime_Travel.Text = "12:00am to 2:00pm" Then
    Set rsSegB = New ADODB.Recordset
    rsSegB.CursorType = adOpenKeyset
    rsSegB.LockType = adLockOptimistic
    rsSegB.Source = "Segments_TimeB"
    rsSegB.ActiveConnection = cn
    rsSegB.Open
    rsSegB.AddNew
    rsSegB.Fields("RouteId") = cmbRouteID.Text
    'rsSeg.Fields("Time_of_Travel") = cmbTime_Travel.Text
    rsSegB.Fields("SegID") = txtSegId.Text
    rsSegB.Fields("segDistance") = txtSegDist.Text
    rsSegB.Fields("SegK") = txtSegK.Text
    rsSegB.Fields("minDensity") = txtSegMinDens.Text
    rsSegB.Fields("MaxDensity") = txtSegMaxDens.Text
    rsSegB.Fields("segRisk") = TxtSegRisk.Text
    rsSegB.Update
    rsSegB.Close
    rs.Close
    cn.Close

Else
    Set rsSegC = New ADODB.Recordset
    rsSegC.CursorType = adOpenKeyset
    rsSegC.LockType = adLockOptimistic
    rsSegC.Source = "Segments_TimeC"
    rsSegC.ActiveConnection = cn
    rsSegC.Open
    rsSegC.AddNew
    rsSegC.Fields("RouteId") = cmbRouteID.Text
    'rsSeg.Fields("Time_of_Travel") = cmbTime_Travel.Text
```

```
rsSegC.Fields("SegID") = txtSegId.Text
rsSegC.Fields("segDistance") = txtSegDist.Text
rsSegC.Fields("segK") = txtSegK.Text
rsSegC.Fields("minDensity") = txtSegMinDens.Text
rsSegC.Fields("MaxDensity") = txtSegMaxDens.Text
rsSegC.Fields("segRisk") = TxtSegRisk.Text
rsSegC.Update
'MsgBox rsegB.RecordCount
'rsSegC.Close
'rs.Close
'cn.Close
End If
Set rs = Nothing
Set cn = Nothing
txtSegDist.Text = ""
txtSegId.Text = " "
txtSegMaxDens.Text = " "
txtSegMinDens.Text = " "
TxtSegRisk.Text = " "
txtSegK.Text = " "
cmbTime_Travel.Text = " "
End Sub
```

```
Private Sub cmdClose_Click()
Unload Me
End Sub
```

```
Private Sub Form_Load()
cn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=C:\Documents and
Settings\etfsa0\My Documents\datademo\Traffic_Data01.mdb;Persist Security
Info=False"
'Fill the recordset object RS
Set rs = New ADODB.Recordset
'rs.CursorType = adOpenStatic
rs.CursorType = adOpenKeyset
rs.LockType = adLockOptimistic
rs.ActiveConnection = cn
rs.Source = "Select RouteID from Routes"
rs.Open
DisplayCurrentRecord
End Sub
Sub DisplayCurrentRecord()
Dim i As Integer
Dim s As String
'If rs.BOF Then rs.MoveFirst
'If rs.EOF Then rs.MoveLast
```

```
For i = 0 To rs.RecordCount - 1
    cmbRouteID.AddItem rs.Fields("RouteID")
    rs.MoveNext
    Next i
End Sub
```

H. Route Data Up-date code

```
Option Explicit
Dim cn As New ADODB.Connection
Dim rs As ADODB.Recordset
```

```
Private Sub cmdAdd_Click()
    rs.AddNew
    rs.Fields("RouteId") = txtRouteID.Text
    rs.Fields("Path") = txtPathID.Text
    rs.Update
    cmdAdd.Enabled = False
    MsgBox "Successfully Recorded"
    DisplayCurrentRecord
End Sub
```

```
Private Sub cmdClose_Click()
    Unload Me
End Sub
```

```
Private Sub cmdDelete_Click()
    rs.Delete
    MsgBox "Record Deleted"
    DisplayRecord
    cmdNext_Click
End Sub
```

```
Private Sub cmdFirst_Click()
    rs.MoveFirst
    DisplayCurrentRecord
End Sub
```

```
Private Sub cmdLast_Click()
    rs.MoveLast
    DisplayCurrentRecord
End Sub
```

```
Private Sub cmdNew_Click()
    txtRouteID.Text = " "
    txtPathID.Text = " "
```

```
cmdAdd.Enabled = True  
End Sub
```

```
Private Sub cmdNext_Click()  
    rs.MoveNext  
    DisplayCurrentRecord  
End Sub
```

```
Private Sub cmdPrev_Click()  
    rs.MovePrevious  
    DisplayCurrentRecord  
End Sub
```

```
Private Sub cmdUpdate_Click()  
    rs.Update  
    DisplayCurrentRecord  
End Sub
```

```
Private Sub Form_Load()  
    cn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=C:\Documents and  
    Settings\etfsa0\My Documents\datademo\Traffic_Data01.mdb;Persist Security  
    Info=false"  
    'Fill the recordset object RS  
    Set rs = New ADODB.Recordset  
    'rs.CursorType = adOpenStatic  
    rs.CursorType = adOpenKeyset  
    rs.LockType = adLockOptimistic  
    rs.ActiveConnection = cn  
    rs.Source = "Select * from Routes"  
    rs.Open  
    DisplayCurrentRecord  
End Sub
```

```
Sub DisplayCurrentRecord()  
    Dim i As Integer  
    Dim s As String  
    If rs.BOF Then rs.MoveFirst  
    If rs.EOF Then rs.MoveLast  
        txtRouteID.Text = rs.Fields("RouteID")  
        txtPathID.Text = rs.Fields("Path")  
        lblRecNum.Caption = rs.RecordCount  
End Sub
```

```
Sub DisplayRecord()  
    Dim i As Integer  
    Dim s As String
```

```
If rs.BOF Then rs.MoveFirst  
If rs.EOF Then rs.MoveLast  
    lblRecNum.Caption = lblRecNum.Caption - 1  
End Sub
```

```
Private Sub Form_Unload(Cancel As Integer)  
cn.Close  
End Sub
```

I. Map Direction indicators code

```
Private Sub Timer4_Timer()  
    frmMap.shp1.Visible = True  
    frmMap.shp2.Visible = True  
    frmMap.shp6.Visible = True  
    frmMap.shp7.Visible = True  
    frmMap.shp5.Visible = True  
End Sub
```

```
Private Sub cmdExit_Click()  
    Unload Me  
    frmMain.lblView.Visible = False  
End Sub
```

```
Private Sub tmr1R1_Timer()  
    frmMap.shp1.Visible = True  
    frmMap.shp2.Visible = True  
    frmMap.Shp3.Visible = True  
    frmMap.Shp4.Visible = True  
    frmMap.shp5.Visible = True  
End Sub
```

```
Private Sub tmr1R2_Timer()  
    frmMap.shp1.Visible = False  
    frmMap.shp2.Visible = False  
    frmMap.shp6.Visible = False  
    frmMap.shp7.Visible = False  
    frmMap.shp5.Visible = False  
End Sub
```

```
Private Sub tmr1Route3_Timer()  
    shp1.Visible = True  
    shp2.Visible = True  
    Shp3.Visible = True  
    shp7.Visible = True  
    shp5.Visible = True
```

End Sub

```
Private Sub tmr1Route4_Timer()
    shp1.Visible = True
    shp9.Visible = True
    shp8.Visible = True
    shp6.Visible = True
    shp7.Visible = True
    shp5.Visible = True
```

End Sub

```
Private Sub tmr2R1_Timer()
    frmMap.shp1.Visible = False
    frmMap.shp2.Visible = False
    frmMap.Shp3.Visible = False
    frmMap.Shp4.Visible = False
    frmMap.shp5.Visible = False
```

End Sub

```
Private Sub tmr2R2_Timer()
    frmMap.shp1.Visible = True
    frmMap.shp2.Visible = True
    frmMap.shp6.Visible = True
    frmMap.shp7.Visible = True
    frmMap.shp5.Visible = True
```

End Sub

```
Private Sub tmr2Route3_Timer()
    shp1.Visible = False
    shp2.Visible = False
    Shp3.Visible = False
    shp7.Visible = False
    shp5.Visible = False
```

End Sub

```
Private Sub tmr2Route4_Timer()
shp1.Visible = False
shp9.Visible = False
shp8.Visible = False
shp6.Visible = False
shp7.Visible = False
shp5.Visible = False
```

End Sub

J. Main Program Code

```
Option Explicit
Dim numroute As Integer
Dim i As Integer
Dim numseg() As Integer
Dim Min As Double
Dim max As Double
Dim sum, sum1 As Double
Dim sumofroute() As Double
Dim sumofsortroute() As Double
Dim MaxRouteSegments() As Double
Dim MinRouteSegments() As Double
Dim sumr1, sumr2, sumr3, sumr4 As Double
Dim Denr1, Denr2, Denr3, Denr4 As Double
Dim Riskr1, Riskr2, Riskr3, Riskr4 As Double
Dim minDensity, minRisk As Double
'needed for connection
Dim cn As New ADODB.Connection
Dim rs As ADODB.Recordset
```

```
Public Function Data_Entry()
    Dim i, j As Integer
    Dim num As Integer
    'numroute = Val(InputBox("Number of Routes", "route size"))
    cn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=C:\Documents and
    Settings\etfsa0\My Documents\datademo\Traffic_Data01.mdb;Persist Security
    Info=False"
    Set rs = New ADODB.Recordset
    rs.ActiveConnection = cn
    rs.Source = "Select * from Routes"
    rs.Open
    numroute = rs.RecordCount
    MsgBox numroute
    If (numroute > 0 And numroute < 6) Then
        ReDim numseg(10)
        ReDim MaxRouteSegments(numroute, 10)
        ReDim MinRouteSegments(numroute, 10)
        ReDim sumofroute(numroute)
        ReDim sumofsortroute(numroute)

        For i = 0 To numroute - 1
            num = Val(InputBox("Segments for route " & i + 1 & vbCrLf & "Bole-
```

```
olmpia-4kilo-6kilo", "Segment Entry"))
    numseg(i) = num
    For j = 0 To numseg(i) - 1
        MinRouteSegments(i, j) = Val(InputBox("Enter Minimu Data", "Data Entry"))
        MaxRouteSegments(i, j) = Val(InputBox("Enter Maximum Data", "Data Entry"))

        'min = MinRouteSegments(i, j)
        'max = MaxRouteSegments(i, j)
        'sum1 = Rand(min, max)
        'sum = sum + sum1
        'sumofroute(i) = sum / numseg
        'MsgBox sum1
    Next j
    'MsgBox sumofroute(i)
    'sum = 0
Next i
MsgBox "Data have been recorded successfully"
Else
    MsgBox "Please enter appropriate route[1 to 5]", vbInformation
End If
rs.Close
cn.Close
End Function

'Random number generation
Public Function Rand(ByVal Low As Long, ByVal High As Long) As Long
    Rand = Int((High - Low + 1) * Rnd) + Low
End Function

' Fix source & Destination
Private Sub cmbDestination_Click()
If ((cmbDestination.Text <> "Bole") And (cmbDestination.Text <> "6 Kilo")) Then
    MsgBox "Does not work for this route"
    cmbDestination.Text = " "
End If
End Sub

'Fix Source & Destination
```

```
Private Sub cmbSource_Click()
If ((cmbSource.Text <> "Bole") And (cmbSource.Text <> "6Kilo")) Then
    MsgBox "Does not work for this route"
    cmbSource.Text = " "
End If
End Sub
```

'This is sub is used to accept the data for the system
Private Sub cmdDataEntry_Click()

```
If cmbTime_Travel.Text = "7am to 9am" Then
    Data_Entry
ElseIf cmbTime_Travel.Text = "12pm to 2 pm" Then
    Data_Entry
Else
    Data_Entry
End If
End Sub
```

```
Public Function bubblesort()
    Dim a, b As Integer
    For a = 1 To numroute
        For b = Count - 1 To b >= a
            If (sumofroute(b - 1) > sumofroute(b)) Then
                sumofsortroute(a) = sumofroute(b - 1)
                sumofroute(b - 1) = sumofroute(b)
                sumofroute(b) = sumofsortroute(a)
            End If
            b = b - 1
        Next b
    Next a
End Function
```

```
'Function to sum total route distance
Public Function Distance() As Double
    Dim sumDistance As Double
    For i = 0 To rs.RecordCount - 1
        sumDistance = sumDistance + rs.Fields("SegDistance")
        rs.MoveNext
    Next i
    rs.Close
    Distance = sumDistance
End Function

'Function to generate random number between the maximum and the minimum
'traffic density, based on Erlange probability function, such that the
'value for accepted probability is set in the equation ( 0.8 in this case)
Public Function GetDensity() As Double
    Dim SumDensity, amin, amax, gnum, avg As Double
    Dim pvalue, k, xy As Double
    Dim x, j As Integer
    x = rs.RecordCount
    For i = 0 To rs.RecordCount - 1
        amin = rs.Fields("MinDensity")
        amax = rs.Fields("MaxDensity")
        k = rs.Fields("SegK")
        avg = (amin + amax) / 2
```

```

'gets also k
Label1:
gnum = Rand(amin, amax)
    For j = 1 To x
        xy = (k * gnum) / avg
        pvalue = xy * Exp(-xy)
        pvalue = pvalue / fact(i)
    Next j
'Make a link with Data for plotting with gnum and pvalue
    'MsgBox "gnum = " & gnum
    'MsgBox "Pval = " & pvalue
    'MsgBox "sumDensity = " & SumDensity
    'MsgBox "GetDensity = " & GetDensity

If (pvalue < 0.8) Then
    'SumDensity = SumDensity + gnum
Else: GoTo Label1
    'MsgBox "gnum actual = " & SumDensity
End If
    rs.MoveNext
Next i
    GetDensity = SumDensity / x
    rs.Close
End Function

```

```

' Function to sum risks on each segment & assign for Route
Public Function GetRisk() As Double
    Dim sumrisk, arisk As Double
    For i = 0 To rs.RecordCount - 1
        arisk = rs.Fields("SegRisk")
        sumrisk = sumrisk + arisk
    rs.MoveNext
    Next i
    'check
    MsgBox "Risk=" & sumrisk
    GetRisk = sumrisk
    rs.Close
End Function
'Defining Minimum function between two variables
Public Function Mini(ByVal a, ByVal b)
    If (a < b) Then
        Mini = a
    Else
        Mini = b
    End If

```

End Function

```
'Comparing the route minimum
Public Function GetMinimum(ByVal r1, ByVal r2, ByVal r3, ByVal r4) As Double
    Dim amin As Double
    If (r1 < r2) And (r2 < r3) And (r1 < r4) Then
        amin = r1
    ElseIf (r2 < r1) And (r1 < r3) And (r2 < r4) Then
        amin = r2
    ElseIf (r3 < r1) And (r1 < r2) And (r3 < r4) Then
        amin = r3
    Else
        amin = r4
    End If
    GetMinimum = amin
End Function
```

```
'checks route for Distance only
Public Sub CheckRoute(ByVal value)
    If value = sumr1 Then
        lblView.Visible = True
        cmdRoute1.Visible = True
    ElseIf value = sumr2 Then
        lblView.Visible = True
        cmdRoute2.Visible = True
    ElseIf value = sumr3 Then
        lblView.Visible = True
        cmdRoute3.Visible = True
    Else
        lblView.Visible = True
        cmdRoute4.Visible = True
    End If
    MsgBox "Route Distance in METER = " & Min
    lblRoute.Visible = True
    lblRoute.Caption = "Free way speed = 60 Km/hr, and it Takes 8 min"
End Sub
```

```
'checks routes for Traffic Density
Public Sub ChooseRoutes(ByVal value)
    If (value = Denr1) Then
        lblView.Visible = True
        MsgBox "The Less Traffic Density routes is => route1", vbInformation
        cmdRoute1.Visible = True
        lblRoute.Visible = True
    ElseIf (value = Denr2) Then
```

```
lblView.Visible = True
MsgBox "The Less Traffic Density routes is => route2", vbInformation
cmdRoute2.Visible = True
ElseIf (value = Denr3) Then
    lblView.Visible = True
    MsgBox "The Less Traffic Density routes is => route3", vbInformation
    cmdRoute3.Visible = True
Else
    lblView.Visible = True
    MsgBox "The Less Traffic Density routes is => route4", vbInformation
    cmdRoute4.Visible = True
End If
End Sub
```

```
'checks routes for Risk
Public Sub SelectRoutes(ByVal value)
If (value = Riskr1) Then
    lblView.Visible = True
    MsgBox "The Less Risky route is => route1", vbInformation
    cmdRoute1.Visible = True

ElseIf (value = Riskr2) Then
    lblView.Visible = True
    MsgBox "The Less Risky route is => route2", vbInformation
    cmdRoute2.Visible = True

ElseIf (value = Riskr3) Then
    lblView.Visible = True
    MsgBox "The Less Risky route is => route3", vbInformation
    cmdRoute3.Visible = True
Else
    lblView.Visible = True
    MsgBox "The Less Risky route is => route4", vbInformation
    cmdRoute4.Visible = True
Exit Sub
End If
End Sub
```

```
'capture database and compare the mimimum distance & risk in time interval A
Private Sub cmdNWA_Click()
cn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=C:\Documents and
Settings\etfsa0\My Documents\datademo\Traffic_Data01.mdb;Persist Security Info=False"
If (optTimeDistance = True) Then
    If (cmbTime_Travel.Text = "7:00am to 9:00am") Or (cmbTime_Travel.Text = "12:00am
```

```
to 2:00pm") Or (cmbTime_Travel.Text = "4:30pm to 6:30pm") Then
    Set rs = New ADODB.Recordset
    rs.CursorType = adOpenKeyset
    rs.LockType = adLockOptimistic
    rs.ActiveConnection = cn
    'Selection for route 1
        rs.Source = "Select RouteID,SegDistance from Segments_TimeA Where
RouteID='r1'"
        rs.Open
        sumr1 = Distance
    'Selection for route 2
        rs.Source = "Select RouteID,SegDistance from Segments_TimeA Where
RouteID='r2'"
        rs.Open
        sumr2 = Distance
    'Selection for route 3
        rs.Source = "Select RouteID,SegDistance from Segments_TimeA Where
RouteID='r3'"
        rs.Open
        sumr3 = Distance
    'Selection for Route 4
        rs.Source = "Select RouteID,SegDistance from Segments_TimeA Where
RouteID='r4'"
        rs.Open
        sumr4 = Distance
    MsgBox sumr4
    Min = GetMinimum(sumr1, sumr2, sumr3, sumr4)
    ' check
    MsgBox "Minimum distance = " & Min

    CheckRoute (Min)
End If
Else

    If (cmbTime_Travel.Text = "7:00am to 9:00am") Then
        'get data related to the time of travel=7:00am to 9:00am
        Set rs = New ADODB.Recordset
        rs.CursorType = adOpenKeyset
        rs.LockType = adLockOptimistic
        rs.ActiveConnection = cn
        'Selection for route 1
            rs.Source = "Select RouteID,SegK, MinDensity,MaxDensity,SegRisk from
Segments_TimeA Where RouteID='r1'"
            rs.Open
            Denr1 = GetDensity
            rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
```

```
Segments_TimeA Where RouteID='r1"
    rs.Open
    Riskr1 = GetRisk
    'sumr1 = Distance
    'Selection for route 2
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeA Where RouteID='r2"
    rs.Open
    Denr2 = GetDensity
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeA Where RouteID='r2"
    rs.Open
    Riskr2 = GetRisk
    'sumr2 = Distance
    ' Selection for route 3
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeA Where RouteID='r3"
    rs.Open
    'sumr3 = Distance
    Denr3 = GetDensity
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeA Where RouteID='r3"
    rs.Open
    Riskr3 = GetRisk
    'Selection for Route 4
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeA Where RouteID='r4"
    rs.Open
    'sumr4 = Distance
    Denr4 = GetDensity
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeA Where RouteID='r4"
    rs.Open
    Riskr4 = GetRisk
    MsgBox sumr4
    'Min = GetMinimum(sumr1, sumr2, sumr3, sumr4)
    minDensity = GetMinimum(Denr1, Denr2, Denr3, Denr4)
    ' MsgBox "Min Density=" & minDensity
    minRisk = GetMinimum(Riskr1, Riskr2, Riskr3, Riskr4)
    ' MsgBox "Min Risk=" & minRisk
    ChooseRoutes (minDensity)
    SelectRoutes (minRisk)

ElseIf (cmbTime_Travel.Text = "12:00am to 2:00pm") Then
    'get data related to the time of travel 12:00am to 2:00pm
```

```
Set rs = New ADODB.Recordset
    rs.CursorType = adOpenKeyset
    rs.LockType = adLockOptimistic
    rs.ActiveConnection = cn
'Selection for route 1
    rs.Source = "Select RouteID,SegK, MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r1'"
    rs.Open
    Denr1 = GetDensity
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r1'"
    rs.Open
    Riskr1 = GetRisk
    'sumr1 = Distance
'Selection for route 2
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r2'"
    rs.Open
    Denr2 = GetDensity
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r2'"
    rs.Open
    Riskr2 = GetRisk
    'sumr2 = Distance
'Selection for route 3
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r3'"
    rs.Open
    'sumr3 = Distance
    Denr3 = GetDensity
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r3'"
    rs.Open
    Riskr3 = GetRisk
'Selection for Route 4
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r4'"
    rs.Open
    'sumr4 = Distance
    Denr4 = GetDensity
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeB Where RouteID='r4'"
    rs.Open
    Riskr4 = GetRisk
'MsgBox sumr4
```

```
'Min = GetMinimum(sumr1, sumr2, sumr3, sumr4)
minDensity = GetMinimum(Denr1, Denr2, Denr3, Denr4)
' MsgBox "Min Density=" & minDensity
minRisk = GetMinimum(Riskr1, Riskr2, Riskr3, Riskr4)
' MsgBox "Min Risk=" & minRisk
ChooseRoutes (minDensity)
SelectRoutes (minRisk)

Else
    'get data related to 4:30pm to 6:30pm

    Set rs = New ADODB.Recordset
        rs.CursorType = adOpenKeyset
        rs.LockType = adLockOptimistic
        rs.ActiveConnection = cn
    'Selection for route 1
        rs.Source = "Select RouteID,SegK, MinDensity,MaxDensity,SegRisk from
Segments_TimeC Where RouteID='r1'"
        rs.Open
        Denr1 = GetDensity
        rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeC Where RouteID='r1'"
        rs.Open
        Riskr1 = GetRisk
        'sumr1 = Distance
    'Selection for route 2
        rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeC Where RouteID='r2'"
        rs.Open
        Denr2 = GetDensity
        rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeC Where RouteID='r2'"
        rs.Open
        Riskr2 = GetRisk
        'sumr2 = Distance
    'Selection for route 3
        rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeC Where RouteID='r3'"
        rs.Open
        'sumr3 = Distance
        Denr3 = GetDensity
        rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
Segments_TimeC Where RouteID='r3'"
        rs.Open
        Riskr3 = GetRisk
    'Selection for Route 4
        rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from
```

```
Segments_TimeC Where RouteID='r4'"  
    rs.Open  
    'sumr4 = Distance  
    Denr4 = GetDensity  
    rs.Source = "Select RouteID,SegK,MinDensity,MaxDensity,SegRisk from  
Segments_TimeC Where RouteID='r4'"  
    rs.Open  
    Riskr4 = GetRisk  
    'MsgBox sumr4  
    'Min = GetMinimum(sumr1, sumr2, sumr3, sumr4)  
    minDensity = GetMinimum(Denr1, Denr2, Denr3, Denr4)  
    ' MsgBox "Min Density=" & minDensity  
    minRisk = GetMinimum(Riskr1, Riskr2, Riskr3, Riskr4)  
    ' MsgBox "Min Risk=" & minRisk  
    ChooseRoutes (minDensity)  
    SelectRoutes (minRisk)  
End If  
'select again ... for code future development, wider network consideration  
End If  
cn.Close  
End Sub
```

```
Private Sub cmdQuit_Click()  
Dim reply As String  
reply = MsgBox("Do you really want to quit?", vbInformation + vbYesNo, "Closing")  
If reply = vbYes Then  
    Unload Me  
End If  
End Sub
```

```
Private Sub cmdRoute1_Click()  
    frmMap.Show  
    frmMap.Left = 8000  
    frmMap.Top = 300  
    frmMap.tmr1R1.Enabled = True  
    frmMap.tmr2R1.Enabled = True  
    frmMap.tmr1R2.Enabled = False  
    frmMap.tmr2R2.Enabled = False  
    frmMap.tmr1Route3.Enabled = False  
    frmMap.tmr2Route3.Enabled = False  
    frmMap.tmr1Route4.Enabled = False  
    frmMap.tmr2Route4.Enabled = False  
  
    MsgBox "Please follow the path", vbInformation, "Route"  
    cmdRoute1.Visible = False
```

End Sub

```
Private Sub cmdRoute2_Click()
    frmMap.Show
    frmMap.Left = 8000
    frmMap.Top = 300
    frmMap.tmr1R2.Enabled = True
    frmMap.tmr2R2.Enabled = True
    frmMap.tmr1R1.Enabled = False
    frmMap.tmr2R1.Enabled = False
    frmMap.tmr1Route3.Enabled = False
    frmMap.tmr2Route3.Enabled = False
    frmMap.tmr1Route4.Enabled = False
    frmMap.tmr2Route4.Enabled = False
    MsgBox "Please follow the path", vbInformation, "Route"
    cmdRoute2.Visible = False
End Sub
```

```
Private Sub cmdRoute3_Click()
    frmMap.Show
    frmMap.Left = 8000
    frmMap.Top = 300
    frmMap.tmr1Route3.Enabled = True
    frmMap.tmr2Route3.Enabled = True
    frmMap.tmr1R2.Enabled = False
    frmMap.tmr2R2.Enabled = False
    frmMap.tmr1R1.Enabled = False
    frmMap.tmr2R1.Enabled = False
    frmMap.tmr1Route4.Enabled = False
    frmMap.tmr2Route4.Enabled = False
    MsgBox "Please follow the path", vbInformation, "Route"
    cmdRoute3.Visible = False
End Sub
```

```
Private Sub cmdRoute4_Click()
    frmMap.Show
    frmMap.Left = 8000
    frmMap.Top = 300
    frmMap.tmr1Route4.Enabled = True
    frmMap.tmr2Route4.Enabled = True
    frmMap.tmr1R2.Enabled = False
    frmMap.tmr2R2.Enabled = False
    frmMap.tmr1R1.Enabled = False
    frmMap.tmr2R1.Enabled = False
    frmMap.tmr1Route3.Enabled = False
    frmMap.tmr2Route3.Enabled = False
```

```
MsgBox "Please follow the path", vbInformation, "Route"
cmdRoute4.Visible = False
End Sub
Public Function fact(ByVal num) As Integer
Dim i, facto As Integer
facto = 1
For i = 1 To num
facto = facto * i
Next i
fact = facto
End Function
```

```
Private Sub Form_Load()
Randomize
End Sub
```

```
Private Sub tmrCarB_Timer()
ImgA.Left = 4920
ImgB.Left = 1440
End Sub
Private Sub tmrCars_Timer()
ImgA.Move ImgA.Left + 30
ImgB.Move ImgB.Left + 100
End Sub
```
